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# Engineering Education

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# *Do You Know—*

► The first returns on plans for the Annual Meeting at the University of Illinois are coming in. Dr. Richard Burington informs us that the Mathematics Division is scheduling two conferences which will be of interest to those concerned with new trends in mathematics as applied to engineering. One conference will deal with "Problems on Training in the Use of Computing Equipment" and the other "The Place of Mathematical Statistics and Probability Theory in Engineering Curricula."

► Computers will also be featured at a Summer School, sponsored by the Electrical Engineering Division, according to Professor L. V. Bewley. He has arranged with the Bell Telephone Laboratory to have several of their leading men in the computer field prepare conferences and possibly demonstrations on digital computers.

► The Humanistic-Social Division will use their Summer School to launch the new program aimed at an investigation of course content and teaching methods in the social sciences and humanities. This is a study to be financed by a grant of $30,000 from the Carnegie Corporation. Its purpose is to make a comprehensive analysis of curricular programs in those colleges which have given considerable thought to the humanistic-social stem. An advisory committee will prepare its own recommendations at the conclusion of the study.

► The ECAC and ECRC will hold a joint dinner on Tuesday evening, commemorating the founding of the first two engineering research experiment stations at the University of Illinois and Iowa State College. A top-ranking speaker has been invited. The dinner will be open to the Society membership.

► The ECRC is planning its General Session around the theme "Portraits in Creative Thinking." This will feature several persons who have made renowned creative contributions in different fields of activity. They will discuss the thought processes involved in creative thinking.

► The Physics Division is planning a conference jointly with several other ASEE Divisions on the subject of "Contribution of Physics in the Engineering Curriculum." This will provide an opportunity to discuss the desirability of introducing more material in advanced physics into the engineering curricula. It will also consider the problem of achieving better integration of curricular material in physics and engineering courses at the sophomore level. Dr. Seeger, Chairman of the Physics Division, is preparing a program which will include some of the country's leading educators in physics and engineering.

► A number of very helpful criticisms have been received on the Preliminary Report of the Committee on Evaluation of Engineering Education. Many of the criticisms have been directed at the two proposals on accreditation. The Committee is anxious to get constructive comments and criticisms on other phases of the report as well. Each institutional committee which is working with ASEE in this project has received a copy of the Preliminary Report. Also, copies were sent to all deans of engineering colleges. Please send comments to Professor Dan

Pletta, Virginia Polytechnic Institute, Blacksburg, Va.

► The Committee on Constitution and By-Laws has approved the following Amendment to By-Law IV, relating to dues:

"Recommended substitute for present Fourth By-Law:

> Within the ceiling limits for dues hereby established, the dues of members may be adjusted annually by the General Council at the same Council Meeting at which the annual budget is considered. The dues shall be so adjusted within the ceiling limits hereby established that over a reasonable period of years the Society shall not incur a deficit that in the opinion of the General Council might endanger continuity of operations.
>
> The ceiling on dues shall be $7.00 per year for those who have not reached their 36th birthday at the beginning of the fiscal year (July 1) and $10.00 per year for all other individual members. Except for the first year after the adoption of this By-Law, the increase in dues approved at any one time shall not exceed $1.00 for individual members. During the first year after adoption of the By-Law, the dues for individual members will be $6.00 for members who have not reached their 36th birthday by July 1, 1954, and $8.00 for all other members."

► The Society this year has a budgeted deficit of $3,700. Our headquarters staff is seriously overloaded. The Society has three office secretaries for 7,000 members. Our total staff averages one staff member per 1500 Society members. Other principal national societies have one staff member to about 300 to 500 members. We are trying our best to provide the necessary liaison with some sixty Divisions, Committees, Sections, Councils, and Branches of ASEE, as well as to take responsible part in activities of ECPD, EJC, and other organizations closely related to ASEE activities.

► A new Committee on Honorary Memberships in ASEE has been appointed, with President Jess Davis as Chairman. This commitee will make nominations to the General Council of individuals to be considered for Honorary Membership. The Committee will welcome nominations from the ASEE members. This is regarded as one of the highest distinctions which the ASEE can confer on an individual. Recipients will be those who have made major contributions to the ASEE as well as to the advancement of engineering education.

Best wishes for the New Year.

ARTHUR BRONWELL, *Secretary*

# On Education, Engineering, and Physics*

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It is well to differentiate at the start between engineering and physics per se. Engineering is concerned primarily with the use of knowledge, particularly for problems of design, whereas physics deals with the understanding of things, particularly matter and radiation in their various energetic forms. Of course, there is many a no-man's land between engineering and physics in such areas as fluid dynamics in physics and fluid mechanics in engineering, as physical thermodynamics and engineering thermodynamics, as electronics in physics and electronics in engineering, et al. Recently, however, the picture has become even more hazy by the introduction of the phrase, engineering sciences.. Strictly speaking, one might consider physics as an engineering science. For the purpose of this discussion, however, I prefer to speak of engineering science in this case as engineering physics.[1] Someone has stated that engineering sciences comprise generally those aspects of physics, chemistry, and mathematics that have been abandoned or neglected by the physicists, the chemists, and the mathematicians. Motivation, however, might be considered a more basic principle of differentiation. Thus one may distinguish between engineering physics which discovers in order to know and physics which knows in order to discover, just as one distinguishes between engineering which is concerned primarily with use of principles and physics which is concerned primarily with their discovery. Incidentally, motivation of engineering students for learning physics must necessarily be the responsibility of the engineering faculty. Too often a student with an enthusiastic interest is left to wander aimlessly in the beginning years of his college course. The teacher of physics is frequently called upon to feed engineering students that are not hungry for engineering—and even less for physics.

The question before us, then, is what educational differences, if any, there should be in the treatment of general physics for physics, and of engineering physics as an engineering science, and of physics for engineering. First of all, may I indicate certain basic assumptions that underlie my own conception of technical education?

### *Basic Assumptions*

In the first place, one can look at anything from three different points of view; namely, aesthetic enjoyment, philosophical relatedness, and technological use.[2] For example, one may look at an object in romantic blue light (i.e., if you like blue), in revealing white light (for neutrality), or in far-reaching yellow light (for visibility). Three different educational patterns emerge depending upon which of these viewpoints is of dominant interest. For want of better names, these can be conveniently labeled literary education, scientific education, and engineering education.[3] It is important for us to realize that the expression of the human spirit is

*Address presented at the ASEE Symposium on Modern Engineering Physics at the University of Florida, June 1953.

[1] C. E. Bennett, "Physics Departments and Engineering Physics Curricula," *Journ. Eng. Educ.* **39**, 421 (1949).

[2] A. N. Whitehead, "The Aims of Education" (New York, 1929).

[3] R. J. Seeger, "Whither Education." *Christian Education*, June (1952).

not confined to any one of these educational schemes, but may be found distinctively to the same degree of imaginative insight in each form.[4]

Secondly, although there are three fundamentally different viewpoints for any given object, one must not forget that a single object persists amid the varied lightings. A prevalent criticism of modern educational practice is that it often fails to emphasize this common objective and to achieve unity among the several courses of instruction, or even unity within a single course. It is high time that we scrap meaningless scraps of information, that we no longer pamper college students as adolescent quiz kids boasting incidental factual knowledge. Educational breadth cannot be measured by spottiness regardless of how far removed the spots are from one another, nor does educational quality consist of informational grains of a mechanical mixture regardless of their fineness. Education should rather be integrated both intellectually and spiritually.

A third basic assumption is the need for steady viewing rather than for transitory impressions. Modern general education in any of its experimental forms, as well as the traditional liberal-arts approach, cannot be confined to one or two years of a student's growth. Any point of view must be developed continuously throughout life.

With these assumptions in mind, namely, three different viewpoints—with respect to a common objective—over a long period of time, let us now consider the teaching of general physics in the following aspects: the development of physical concepts, the nature of these concepts, the use of the concepts.

Some kind of general or liberal education is vitally needed as much—perhaps even more so—by specialists than by others. It is just as important that a physicist see physics in its cultural matrix as in its technological pattern. Too often, however, so-called general education consists merely of compulsory courses filled with wonders about scientific facts and with the magic of the scientific method. A truly collegiate approach must be essentially intellectual and, therefore, conceptual. Appreciation of the evolution of concepts is rarely developed owing to a feeling of antiquarianism in view of rapidly changin physical theories.

### *Creative Imagination*

Perhaps the first point to stress here is the use of creative imagination at all levels of expression. In this connection, I have been greatly impressed by the artistic creativity of children. The art itself is exceedingly primitive, but the effort is genuine and interesting. It seems to me that intellectual curiosity and expressive creativity ought to be developable equally well in kindergarten science. After all, the spirit of the kindergarten, the laboratory, and the studio is essentially the same.[5] Of course, if one is going to develop such creativity, one needs relaxation periods and marginal leisure.

It is quite important, moreover, that the role of insight be appreciated in the use of the scientific method and in the development of theoretical concepts. Insight, however, can not be taught; at best, perhaps, its spirit can be taught. In this connection, one might well use case histories involving the development of particular concepts, a sort of inductive approach from the particular to the general.[6]

The evolution of concepts must not only be viewed in their imaginative context, but also be traced in historical currents of thought. The student should be made aware that the phlogiston theory was practised long after the establishment of the conservation of mass by Lavoisier, that the caloric theory was used both by physicists and engineers long after the fundamental idea of heat as a mode of

[4] R. J. Seeger, "Phenomena and Imagination," *Sci. Monthly* **72**, 148 (1951).

[5] E. Schrödinger, "Science and Human Temperament" (New York, 1935). R. J. Seeger, "Our Physical Heritage" (Ann Arbor, 1938).

[6] I. B. Cohen and F. G. Watson, "General Education in Science" (Cambridge, 1952).

motion had been conceived, that Avogadro's hypothesis accepted now as a cornerstone of molecular theory was regarded as incorrect by John Dalton, the father of modern atomic theory, that the relativity theory ascribed by some to the insight of Ernst Mach was actually opposed by him. The historical evaluation of concepts will present the young student with a realistic approach to concepts undergoing evolution in his own scientific world.

Equally significant are the philosophical implications latent in physical concepts at various stages of their development.[7] The simple relationship that force is equal to mass times acceleration has been regarded by some as a definition of force, by others as an experimental law. No wider divergence of philosophical meaning can be found. It envelops completely the intellectual understanding of the concepts involved, particularly, the concept of physical causality. It is necessary for a student to realize the restricted meaning of causality in his scientific work. Then, too, the philosophical implication popularly understood of relativity theory is often in direct opposition to that theory. Of course, all motion is relative to the observer; this fact was generally appreciated by the Greeks and carefully enunciated in the Galileian principle of relativity. The contribution of Einsten was to extract the invariant characteristics independent of the motion of an observer.

The social criteria for the acceptance of scientific theories also must not be neglected; they include many extra-scientific factors. One important factor is common sense which often amounts to the familiar residue of the science of a preceding generation. Another factor is elusive simplicity. For example, the acceptance of the Ptolemaic hypothesis in preference to the Copernican one was due largely to its supposed simplicity. Likewise, the concept of inertia, which appears natural to us nowadays, was so unnatural in the framework of Greek culture that it was ignored there. Physicists today, in turn, are confronted with an increasing number of so-called elementary particles. Up to now, the particle concept has been retained because of its simplicity even though material corpuscles are generally recognized as not satisfying uniquely the definition of a particle in view of their wave-like characteristics under certain experimental conditions. It may well be that the old particle concept has outlived its heuristic usefulness in view of the new complexities that have arisen.

This understanding of the development of concepts from historical, philosophical, and social viewpoints, I believe, is equally important for beginning students whether in physics or in engineering physics or in physics for engineers—indeed, both for scientists and for engineers, as well as for non-scientists.

Let us now consider the concepts per se. With respect to the status of general physics in colleges, one can perhaps remark sorrowfully "too much and too late," as I noted some time ago when I had occasion to review the concepts actually being taught in fluid dynamics.[8]

### *Physical Concepts*

The first question that arises is the selection of physical concepts. Evidently, one cannot treat them all; indeed, in view of their different significances one should not treat all equally. One is forced to select certain primary principles including some recently discovered. In studying these selected concepts one requires firsthand acquaintance with them. There is real danger today, however, that people will become merely arm-chair scientists, content always with secondhand knowledge. Passive observance is insufficient; active participation is necessary. One requires laboratory work for general training in observations and measurements. I doubt if any physics teacher believes he is giving instruction in the complete scientific

[7] P. G. Frank, "Science and Philosophy" (Unpublished notes 1953).

[8] R. J. Seeger, "On Fluid Dynamics in Physics Teaching," *Amer. Journ. of Physics* **21**, 29 (1953).

method through his laboratory assignments. Laboratory experience, however, can assist in clarifying the nature of specific concepts as well as in developing an appreciation of the limitation of their general validity.

It is important also that one views the concepts of a discipline in their entirety, in their inter-relatedness with one another, and in their relatedness with those of other disciplines. For example, the acoustics student should appreciate the relation of impedance to the resistance of the electrical student. The student of mechanical energy should know its relation to thermal energy. In this connection, economy in the organization of thought should be outlined to the student—the presentation must necessarily be largely deductive. This doesn't mean, of course, that the introduction to primary concepts should not be made on a simplified, particularized basis. The engineering physicist and the engineer, above all, should be greatly interested in the organized body of knowledge which permits efficient organization of action.

One must not be content, however, just with understanding a group of selected concepts, with having firsthand experiential knowledge of them, with appreciating the logical deductions that can be derived from them. What is probably most important in a practical world is that a student should be made humbly aware of the limitations of his theoretical knowledge. At all educational levels there should be maintained continually a direct comparison with observed facts. The concepts, in short, should be living concepts, alive in their historical development and alive in their very nature. In this respect, I believe that the physicist and the engineering physicist will both profit by the same approach to physical concepts. The design engineer, however, may rightly be concerned less with the theoretical aspects. Parenthetically, mathematics should be used in all instances wherever it organically affords natural comprehension; it should not be employed as a fetish distracting from the physical truths.

*Doers rather than Viewers*

It is in the use of concepts, however that a sharper differentiation may profitably be made educationally between the engineer and both the engineering physicist and the physicist. In view of the traditional liberal-arts origin of much of American higher education, it is not surprising that the inertia of Platonic idealism has motivated against the study of useful thinking.[9] You may recall that Plato was not interested in triangles of imperfect materials, but preferred to contemplate the idea of a perfect triangle. Accordingly, his school was more concerned with contemplation than with action. Nowadays, however, we live in a practical world rather than in a theoretical one. We are doers rather than viewers. It is important, therefore, for all students to know how to use concepts, which will become more generally meaningful when used to solve particularized problems. The problems may take one of two major forms: first, problems that promote the understanding of the concepts themselves, and, secondly, problems that deal primarily with the technical use of the concepts. I should like to stress again that a high level of imagination is required to solve both types of problems. It is to be expected, however, that physicists will be more interested in problems of understanding, whereas engineers will be more interested in problems of use. Engineering physicists have interest in both types of problems, but to a less degree in each case. It is possible that physics courses may be differentiated at this point, at least, in discussion sessions. Such courses for engineers can presumably be taught equally well by an engineer with an understanding of physics or by a physicist with an appreciation of engineering.

*Advanced Courses*

So far, we have considered only college general physics. A few words, in con-

[9] G. Sarton "History of Science" (Cambridge, 1952).

clusion, may not be out of place with respect to certain advanced courses involving several disciplines, usually offered at the junior-senior level. For example, mechanics may be taught in a mathematics department or in a physics department or in an engineering department. So, too, thermodynamics may be taught in a chemistry department or in a physics department or in an engineering department. Electronics may be studied either in a physics department or in an electrical engineering department. It is my personal belief that at this level any student should have as broad a base as possible. Thus it is desirable for an engineer to understand the approaches to mechanics both by a physicist and by a mathematician, as well as by an engineer, and vice versa. To achieve this end a single course might be offered in junior-senior mechanics, a course that would be under the planning cognizance of a faculty committee comprising representatives of each of the three departments mentioned. Such a course could be given by a man in any one of these departments—perhaps, on a rotational basis—provided only that the individuals so selected would have the breadth of interest of all the departments involved. Not only would there be economy in such a procedure, but, what is more, far-reaching educational values. Just as intense specialization within a field begins properly at the graduate level, so, I believe, broad specialization in a field begins properly at the undergraduate level.

In view of my association with the National Science Foundation, it would not be unexpected that I should urge that research and education should be combined to some degree at all levels of college instruction. The spirit of research should permeate even a college course in general physics; some activity of research, indeed, might well be associated with advanced undergraduate courses. The quest for knowledge has always been a race of mankind toward a tantalizing receding goal of truth. The lighted torch must be handed on from generation to generation, from individual to individual. Disinterested curiosity, however, is insufficient in a world of engineering that demands practical action as well as aesthetic enjoyment and creative thought.

# College Notes

Beginning in 1954 **North Carolina State College**, the **University of Florida**, **Virginia Polytechnic Institute** and the **Southern Regional Education Board** will jointly sponsor cooperative Graduate Summer Sessions in Statistics.

The summer sessions are designed to carry out a recommendation of the Southern Regional Education Board's Commission on Statistics, on which the three institutions initiating the program are represented. They will be of particular interest to (1) research and professional workers who want intensive instruction in basic statistical concepts and who wish to learn modern statistical methodology; (2) teachers of elementary statistical courses who want some formal training in modern statistics; (3) prospective candidates for graduate degrees in statistics; (4) graduate students in other fields who desire supporting work in statistics; and (5) professional statisticians who wish to keep informed of advanced specialized theory and methods. Each of the summer sessions will last six weeks and each course will carry three semester hours of graduate credit, with a maximum of six semester hour credits earned in one summer.

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# Accrediting of Engineering Curricula*

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Twenty years ago the engineering societies began to consider the possibilities of accrediting engineering curricula throughout the United States. The American Institute of Chemical Engineers began in the twenties to examine curricula and accredit them for their own listing. The National Council of State Boards of Engineering Examiners prepared a list before Engineers' Council for Professional Development had set up its procedures. One of the reasons for the organization of Engineers' Council for Professional Development in 1932 was the accrediting of engineering curricula. The Committee on Engineering Schools was organized at the first meeting and then at the first annual meeting of the organization, the Committee reported a procedure by which it proposed to accredit engineering schools. First inspections began in 1935 and by 1937 the inspections were in full force throughout the United States.

During the early days of ECPD, Dr. Karl Compton, then President of Massachusetts Institute of Technology, acted as chairman of the Committee on Engineering Schools. He and his Committee outlined the general philosophy of ECPD accrediting.

### *The Philosophy of Accrediting*

From the very first it was realized that all curricula within the same school were not of the same calibre. It was, therefore, decided to inspect and accredit by curricula rather than by institutions. This decision had a far-reaching effect because it sent the inspectors into the schools not only to look at their general finances, admissions and organization but to actually inspect what was going on within the several curricula themselves. No blanket accreditation was given.

Inspection committees went even further. They inspected the supporting departments of mathematics, chemistry, physics, English, economics, geology, etc. These inspections of supporting departments probably led to some of the criticisms of the inspecting procedure in general. This I will discuss a little later.

Engineers' Council for Professional Development was a conference of five engineering societies: the American Society of Civil Engineers, the American Institute of Chemical Engineers, the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society for Engineering Education, and the National Council of State Boards of Engineering Examiners. Later was admitted the Engineering Institute of Canada. These eight bodies have comprised Engineers' Council for Professional Development.

In the early days of accrediting, it was obvious that the curricula represented by the societies should be inspected and accredited. From the very beginning, it was thought that additional curricula should be inspected and added to the list. There were variations of these major fields, such as mining and metallurgy. The question would, of necessity, be raised as to whether these should be accredited as separate cur-

* Presented at the Annual Meeting of ASEE, University of Florida, June, 1953.

ricula or one curriculum. By 1938, sixteen different curricula had been accredited.

It was not long before the institutions began to present such programs as engineering physics, geological engineering, engineering mathematics and geophysical engineering. These programs apply engineering and mathematical principles to fields not normally counted as major fields of engineering. The problem is still before the Education Committee and will probably be solved within the next two or three years.

From the very beginning, it was understood that no curricula would be accredited that were not degree-granting departments in engineering and been in existence long enough to have graduates. As a matter of fact, instructions to the committees are that they inquire into the success of the graduates of the several programs.

### *What Criteria Are Involved?*

The early committee set the general tone of the inspection and accrediting procedure. There must be intellectual atmosphere within the institution. Effort was made not to standardize, but to detect an intellectual atmosphere and climate. The early instructions to an inspector were to avoid giving recommendations which would tend toward standardization. Committee members could discuss problems with the different departments being inspected, but it was not thought good for the inspectors to recommend standardization, number of hours, and other activities which departments should undertake.

It was of paramount importance that there be competent faculty and enough faculty members to insure stability. A one-man department was looked upon with disfavor for the simple reason that if one man left the institution, the whole program might be changed so radically that it would not be the same program which was accredited. Faculty members should show evidence of intellectual activity by their contributions to the technical press, the writing of books, and the preparation of manuals and instructions for their students. It is also considered evidence of good atmosphere if the faculty members were members of their technical societies and took an active part in the American Society for Engineering Education.

The committee realized that there could be excellent faculty members who were not writers or joiners, yet these, generally, were counted as evidence of activity in the field of development of the engineering profession.

There, of course, must be a minimum of facilities, such as laboratories, libraries, etc. The committees were expected to examine the laboratories, look at laboratory reports, laboratory manuals, and student work. They were to examine the libraries, ask the librarian who was interested in books, to determine whether the atmosphere was one of studious application or one in which books did not count.

There must, of course, be ample financial support to protect the institution against lean years or against loss of students. An institution which depends wholly upon student fees was not counted as stable as one which had good state support or adequate endowment.

Inspectors reviewed the content of curricula, going over the whole program with members of the staff, asking questions regarding particular courses—the content, textbooks, types of reports required, etc. It has always been counted very important to discover what was going on in the classroom and the laboratory and the reactions of students to the instruction given them.

Inspectors examined course outlines, examination papers and examinations. They asked for samples of student work showing students' papers with failing marks, with just passing marks, and with good marks. After all, the educational process is for the benefit of the student, and it is the effort of the inspector to determine whether or not the student is growing from a freshman to a beginning engineer at his graduation.

Not only is the inspector interested in the facilities, courses, and so on, but he is interested in what the graduates have done after they have left the school.

Many schools have very good records of graduates' performances. Others have meager records. It happens that at the present time graduates from all institutions are finding excellent employment in industry because of the great scarcity of engineering students.

### *Who Is Inspected?*

Engineers' Council for Professional Development decided early in the inspection procedure to visit only on the invitation of the institution itself. There was no desire on the part of the engineering societies or the National Council of State Boards of Engineering Examiners to go into schools which did not wish to be inspected. The actual inspection was to be made by members selected by the professions themselves. Each member of Engineers' Council for Professional Development, except the Canadian Institute, named a series of inspectors in the several zones of the United States. The chairman of the Committee in each zone normally calls upon the members of his zone to do the inspection. In the early days of 1935 and 1936, the chairmen of committees of all zones aided with the inspections in New England and the Middle Atlantic states in order that there might be uniformity. Uniformity is again insured because the Committee reports are reviewed by the whole Committee on Education.

Visits to the campus are made at the convenience of the institution and the members of the delegatory committees. The chairman of the committee gets in touch with the institution and arranges dates for the inspection. The inspectors spend from one to two days at the institution inquiring into the many matters suggested under the criteria of inspection.

After the visit they make reports to the Committee on Education and it, in turn, reports to ECPD. Work on the Committee on Education is a rather strenuous activity. All reports are reviewed at meetings of the Committee and the recommendations are made to ECPD itself. No delegatory committee or even the Committee on Engineering Education can accredit a program. This is done by the council of Engineers' Council for Professional Development. The whole process is highly confidential. Reports are made only to the Committee on Education and these are counted confidential by the Committee itself. The reporting of accredited curricula in the annual reports of ECPD show only accreditation and not whether it was provisionally accredited or whether it is fully accredited. As far as the public is concerned, a provisionally accredited program has the same standing as a fully accredited program, the only difference being that an inspector is expected to return to the institution after a short period of time to see if the desirable progress has been made toward the full accreditation.

After the findings of the Education Committee are presented to ECPD and acted upon by the Council, the Secretary of ECPD notifies the institution of the action of ECPD. Detailed information may be given by the chairman of the Education Committee or by the regional chairman. Usually, the regional chairman is asked to prepare a letter to the institution if the accreditation is provisional rather than full accrediting. In any case the administrative authority of the institution may ask for detailed information, and it will be furnished by the regional chairman from the reports of the inspectors who visited the institution. Ordinarily, verbatim reports of the inspectors are not furnished the institutions because it is desirable to have the inspector report confidentially to the Education Committee of ECPD. It is not desirable to send derogatory statements to the institution, and it is undesirable for the committee member to include derogatory statements unless they are absolutely warranted.

Accrediting has become so general in the United States where societies and agencies of particular courses are requesting the institutions to receive them to accredit their programs that the colleges have organized the National Accrediting Association which has been examining the general problem of accrediting with the

idea of reducing some of the visits to the several campuses and particularly the tedious questionnaires that are now being required.

At first thought, it seemed possible for some regional agency to accredit the whole institution and thus let this accrediting provide for all the needs of all the agencies needing to know about curricula. After study of the programs of the several agencies the regional accrediting associations which were to do the accrediting as recommended by the National Council of Accrediting has been working cooperatively with such agencies as Engineers' Council for Professional Development to develop procedures which are desirable to get detailed information about courses and, at the same time, avoid great duplication of information by the institutions.

Such matters as financial status, general operation, cost and size of endowment, books in the libraries, work in basic departments such as math, physics and chemistry, might well be inspected once and then not have to be inspected by each professional agency which wishes to get information regarding professional programs.

*Cooperative Inspections*

At the present time, there is on effort to develop cooperative inspections to avoid duplication. It is probable that within the next two or three years better procedures will be developed. It is further probable that Engineers' Council for Professional Development will continue the type of accreditation that it is undertaking. It is so desirable that curricula be accredited rather than institutions that it hardly seems feasible for one inspection to take care of medicine, law, all phases of engineering, and other professional fields.

The work of Engineers' Council for Professional Development has been outstanding in the field of accrediting. Excellent records have been accumulated. D. C. Jackson in 1939 wrote a report on engineering curricula and determined by the reports of delegatory committees. Much improvement has been accomplished throughout the United States. The problem of fringe curricula is under consideration and will be solved within the next two or three years. The problem of inspection will be simplified during the next few years and, in all probability, it will be generally recognized that the inspections of ECPD are fair and that they are beneficial not only to the institution, but certainly to the constituent bodies of Engineers' Council for Professional Development.

**ANNUAL MEETING**

***June 14-18, 1954***

**University of Illinois** **Urbana, Illinois**

# This Above All*

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The theme of this session, Education *or* Research, is significant in that an entirely different meaning is obtained by changing the *or* to *and:* Education *and* Research. To me, education and research are synonyms for an inquisitive search for the truth. Why this choice of words in the theme? The answer is that a feeling of uncertainty or even resentment is shared by many engineering instructors because of a distinct conflict which exists between the demands of teaching and the demands for published research. Unfortunately, this conflict is not apparent to all observers and my purpose will be to show how it arises and how it can be overcome.

### *Research*

What is meant by research? Every *true* teacher of engineering does research as a normal part of his duties where by research I mean studious inquiry or experimentation leading to previously unknown facts. This research may not lead to publication unless considerable time is spent in improvement and enlargement. The research may even be done in a consulting capacity. But, undoubtedly, this is not the meaning that underlies the theme. Here research implies *published* research and published research implies extensive investigation. One can justifiably argue that only published research can be effectively evaluated. Two other distinctions should be noted: Research may be entirely analytical or else depend heavily on experimentation. It is the latter form which we mainly encounter in the heat power field and, for this reason, our problem is somewhat singular.

Should the engineering teacher consider research to be a part of his job? The answer is an unqualified "yes" because teaching and research are inseparable companions—the research environment is the teaching environment. Should the engineering teacher consider published research to be a part of his job? The answer is again "yes" for a number of reasons: the instructor should have experienced all aspects of research if he is to guide graduate students; the writing of a paper places the man in a position which he may have to defend and so develops his personality; the personal satisfaction of achievement cannot be ignored since it will be reflected in his ego and therefore in his teaching presentation. But now the title of this paper comes into play. Research and teaching are inseparable but published research, *and other activities as well, may* demand time that can interfere with teaching responsibilities. What has been your decision when such interference is encountered? What does your administration do to eliminate the interference?

### *Duties of the Teacher*

Let us list all of the duties or the responsibilities of the engineering teacher. First, of course, we list his teaching assignments if only because we must pay lip-service to this activity:

1) Class work
2) Supervision of courses taught by others
3) Supervision of advanced degree candidates

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4) Supervision of staff employees
5) Counselling students
6) Registration activities
7) Research
8) Committees of the University
9) Committees of the professional societies
10) Student chapter or branch supervision

The reason that a conflict may exist between published research and teaching is not revealed by the items on this list, formidable as they might seem, but between the lines of the list. For example, the class work of an engineering teacher in a large school may consist of only one graduate course plus supervision of a number of graduate students. This man would declare that no conflict exists between teaching and published research. But the teacher in another school may not have graduate assistants and shop help. He must do his own library search in, usually, an inadequate library; he must do his own experimentation and make his own equipment; he must do his own drafting and, in most cases, type his own paper. On top of all this, his teaching load may be excessive. An example was furnished by a friend of mine who quit his post at a large university this year for a job in industry. One semester he had three sections of a three lecture hour undergraduate course; one section of another three lecture hour undergraduate course; one seminar course; one graduate three lecture hour course; one MS and one PhD candidate; and he also had committee tasks for the school. I am aware of many other instances where little time is available for publishing research and for other activities.

It should also be mentioned that there are many teachers who enjoy classwork and committee work but not extended research. I know men of this type who do a splendid job of teaching in all aspects of the work. Unfortunately, however, in this group will also be found mediocre teachers who are interested only in personal activities and those who are afraid to think for themselves. Here the excuse of teaching is used to rationalize the avoidance of research in any form. But if the administration has a promotion policy that demands research, cases of this type would be few.

### *Teaching and Extended Research*

Let us return to the responsibilities of the engineering teacher. Suppose that most of the items on the list can be found on his schedule in whole or in part. Is it still possible to have publications? The answer is a definite "yes" if his graduate school is good, and a definite "no" for the contrary case. Unfortunately, the administration may measure the man in the undergraduate type school with few or no publications and many duties against the man in the graduate type school with many publications and few duties. When this occurs, and it always will with human nature what it is, not much can be done. Even if the administration were to free the man from all teaching duties, progress would not be made for some time. This is because research is becoming big business (and, is this desirable?). A library study that might have taken one month before the war, may now require three months because of the increased volume of publication. Student salaries have doubled and assistant salaries have tripled. I have not seen a good analysis of graduate student cost because such data are difficult to separate from overhead cost. My estimate would be $4,000.00 for each MS candidate (1 year), and $9,000.00 for each PhD candidate (2 years). These estimates are based upon stipends for the student, salaries for the teachers, overhead, materials, and graduate classes of 8 students; the figures can be greatly reduced by doubling the enrollment, ignoring overhead, and including tuition. For examples of costs: IBM calculations for a PhD thesis cost $500.00 in one instance, and the most desirable calculations would have cost $1,500.00; a flow chamber of limited utility (PhD thesis) required 300

man hours of labor, or roughly $900.00. The machine tool investment in a good experimental shop and instrument cost are also items of some magnitude (despite the free gifts of our bountiful government).

There are some who say that the instructor must do extended research as an essential part of his teaching presentation. For the research problem that demands experimental work, I am quite certain that effective teaching would be impaired if the instructor were required to do all of the drudgery associated with the problem. No, the people who claim that such research stimulates teaching have in mind the aftermaths of research—the supervision of research—the culling of ideas for theses—the seminars on related problems —and the consultations between student and instructor.

### *Research by Decree*

Because of the costs of graduate instruction, and because of the drudgery associated with a thorough and complete investigation, a new form of subsidy has appeared: government projects. It is now possible for every teacher to be the guiding genius for a research team. He not only avoids drudgery, but he can time his own hours and therefore set his own paycheck. The quality of his work will be in direct ratio to the quality of his hired assistants. If the farmers are entitled to subsidies, certainly the schools and research are entitled to the same consideration (or are they?).

One other aspect of the publication problem should be mentioned. Is it ethical to place your name on a paper when, perhaps, you did not fully contribute? If the teacher suggests the topic, is he then a co-author? One large research unit has a rule: Do not place your name on a paper unless you are prepared to defend it—odd—I can defend the Bible. Administrations may berate the man without publications, but do they then investigate the unusual circumstances of too many publications?

### *Conclusions*

Although we have selected published or extended research as the offender, it is apparent that other activities can interfere with teaching. It can be concluded in most instances:

1) It is highly desirable for the engineering teacher to do research.
2) It is desirable for the engineering teacher to publish his findings.
3) The administration should have definite policies:
   a) If published research is the keynote for promotion—say so.
   b) If published research is demanded, the teaching load and the pay structure should complement the demand.
   c) If the man who neglects to publish is reprimanded, so should be the man who neglects other responsibilities.

My advice to the young teacher and to the young engineer is to divide his time and therefore his responsibilities in the ratio demanded or implied by his employer. If, because of this division, certain things cannot be done in the manner that they should be done, the remedy is simply the title of this paper.

# Stimulation for Study in Engineering*

By J. L. MERIAM

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## I. *Introduction*

Engineering education in this country has not been entirely unsuccessful in the past decade or two as is evidenced by the intimate parts which our recent engineering graduates are now playing in all phases of modern engineering development. Despite such evidence of success, a continuing critical review of our philosophy in engineering education is needed. It is perhaps our ready willingness to criticize ourselves which is largely responsible for that measure of success which is ours. The purpose of this paper is to present constructive criticism which bears upon an underlying philosophy of both phases of our overall problem, namely, the structure of our engineering curricula and the teaching which is carried out within that structure. This discussion centers around the psychological basis for learning and thereby attempts to establish the genuine need for including in our curriculum an intimate and continuing contact between the student and real engineering problems with professional implication. It is suggested that this contact be effected through a problem course that would parallel the usual courses in the regular program and that would continue throughout each undergraduate term of study. In this course there would be presented engineering situations of a more comprehensive nature than those considered in individual courses where of necessity the topics and methods covered are of restricted scope. The use of such comprehensive engineering situations is considered necessary for the stimulation of effective study in engineering.

## II. *Forces of Learning*

To lay a foundation for proper consideration of the case for a separate and continuing course in engineering problems it is first desirable to examine the nature of the forces that lead to learning. In Barlay's dictionary of 1792 the term "school master" is illustrated with a picture of a small tearful boy standing on a three-step platform before the school master who, with speller in one hand and switches in the other, is extracting the day's spelling lesson from his pupil. The platform is labeled "The Ladder to Learning." The force that causes the small boy's performance is an *inducement* which is clearly the threat of physical punishment and accompanying humiliation. In more recent years pupils have received more humane inducement to learn the conventional school subjects.† After school is over for the day, however, children learn in a very different sort of way. They

* Presented at the Annual Meeting of ASEE, Educational Methods Division, Univ. of Florida, June, 1953.

† The "activity method," formerly called the "project method," is now widely used in our lower schools as a means of inducing pupils to learn the conventional school subjects. The method consists of bringing the pupils into closer contact with these subjects by means of projects and activities which interest them. By and large the immediate objective of this method as used seems to be the mere learning of these subjects rather than the accomplishment of worthwhile activities aided by these subjects. There is an important difference in viewpoint here on the objectives of the method about which educators are in considerable disagreement.

engage voluntarily in activities that are of interest to them and learn to be proficient in these activities at a rapid rate. This proficiency in learning is due mainly to an inner compulsion or *motive* for action stimulated by the interest and meaningfulness of these activities. Adult learning is not unlike child learning in principle—a driving force is needed in each case—and differs mainly in maturity of purpose and in development of power for analysis and synthesis. Driving forces that cause learning activity for child or adult may be identified in two ways as described by the words "inducement" and "motive." An inducement is an external force that leads one on to activity or that moves by persuasion. Inducement is *extrinsic* as the source or reason for action has come from without the individual. On the other hand motive is a force that comes from within the individual and incites him to action. Motive is then *intrinsic*. The small boy struggles with his spelling lesson by extrinsic inducement but learns to play marbles by reason of an intrinsic motive. The different role of each of these two kinds of force in the learning process needs careful study both by teachers of engineering and educators in general. It is the essential purpose here to point out that learning activity generated by *intrinsic* forces is far more intense and fruitful than is activity extrinsically generated. Genuine interest based on inquisitiveness and the desire to accomplish is the spark which ignites intrinsic force and generates a true desire to learn. It is a major responsibility of the teacher to arouse and maintain these interests that in turn generate intrinsic forces of learning. Interest is by far the strongest catalyst for learning.

It would be very revealing if an honest classification could be made of all requirements imposed on and activities expected of the average engineering student during his entire course of study to see whether they result mainly in intrinsic desire to learn or mainly in extrinsic inducement to performance. For instance, are our engineering students aroused in their calculus course to discover for themselves the physical and geometrical interpretation of the integral with the aid of reality in practical application, or are our students induced to study this concept largely as a required manipulation of symbols and exercise in logic? Is the student in basic mechanics presented with interesting problems of practical value that generate a desire on his part to learn about the action of forces, or is he more often induced to equate certain force sums to zero in order to check an answer and to satisfy a required exercise in mental discipline? Do our rigid assignments, formal lectures, and frequent examinations promote activity most conducive to learning, or are they largely inducements to performance? These and other similar questions need honest answers. It appears as though we push our students up "The Ladder to Learning" by inducement considerably more than we stimulate them to climb under their own motive power.

It is not the intent here to suggest that all extrinsic inducement to learning can or should be eliminated. Competition for improved social and economic status provides strong extrinsic inducement which is an integral part of our system and must be accepted. The intent is, however, to point out that learning which arises from extrinsic inducement is highly superficial compared with the more penetrating learning stimulated by genuine interest. Therefore, in seeking to improve materially the education of engineers we should look carefully in the direction of increasing the kind of stimulation that results in intrinsic desire to learn. This can be done by providing from the start of the freshman year an environment of subject matter and teaching which presents a wealth of interesting reasons for technical study.

### III. *Doing and Learning*

Up to this point attention has been drawn to those forces which stimulate learning. Such forces, although necessary, are not sufficient to result in effective

learning. Learning may be likened to mechanical work which requires both force and movement. Regardless of the magnitude of the force no work is done without movement. Similarly with learning, the compelling force must be accompanied by action on the part of the learner. "Learn by doing" is a descriptive statement of how we learn. It places emphasis on doing and implies the simultaneity of learning and doing. It is encouraging that recognition of this principle has been given in recent articles on engineering education.

From the standpoint of a statement of objectives it may be pointed out that the saying "learn by doing" should be inverted. The inverse, do by learning, states the objective, which is accomplishment, and describes the means of reaching this objective, namely, through learning. In his book "The School and Society" John Dewey said "Think of the absurdity of having to teach language as a thing by itself. . . . There is all the difference in the world between having something to say and having to say something." It is equally absurd in engineering to teach such basic subjects as mechanics and thermodynamics as disciplines by themselves. In these courses, aided by competent instruction, students will learn how to *analyze* problems such as the rolling wheel and Carnot cycle efficiency. But virtually no attempt is made for the simultaneous synthesis of this knowledge. This synthesis, which requires the understanding of the relationship of the particular tool to the whole of a real engineering problem in which the tool is needed, is a very definite part of the learning of this tool. In reality the need for synthesis in real engineering problems is the main reason for analysis. Inasmuch as learning and doing are basically coexistent, it follows that for the kind of learning with which we are concerned in engineering, analysis should not be taught without ample supporting synthesis at the same time. Doing in engineering involves both.

One often hears it said that our students should receive thorough training in the disciplines fundamental to engineering. Mental discipline in itself is of little or no importance but is a natural consequence of learning how best to reach a goal of engineering achievement. Little mental discipline can be taught until it begins to function in the course of reaching a worthwhile objective. In engineering, doing, in the sense of dealing with real situations, is our objective, and every possible emphasis must be placed on this kind of doing in the preparation for engineering work.

## IV. *Need for Motives in the Study of Engineering*

The amount that students actually learn compared with the amount of material covered is an index to the efficiency of our educational system. If such a correlation could be obtained quantitatively, it would, in all probability, be a shock to most of us to see how low it would be. Somewhat qualitatively however, we can measure in our minds what this efficiency is in particular areas. The conclusion we face is that this correlation is far too low, particularly in the first years of engineering study where preparatory courses in science and engineering are undertaken. Let us turn to the principles of learning for explanation. Since learning and doing are basically coexistent can we justify such a large time gap as presently exists between instruction in the basic physical and engineering sciences and opportunity for their use in real engineering situations? Can we justify the present overwhelming predominance of extrinsic persuasion in our curricula and teaching? What objective does this persuasion result in for the student—inquiry and achievement, or merely the passing of next week's examination? Does our present system give maximum encouragement for originality and ingenuity which have been sparked by intrinsic desires? Do we make adequate allowance for individual differences in students? Are our most competent and influential instructors placed

in charge of the introductory courses in which the need for orientation and stimulation of interest is greatest? Unfortunately, the answers to these questions are preponderantly in the negative. There is need for considerable study and action on our part in order that positive answers to these and similar questions may be given.

The design of present engineering curricula has been influenced largely by retrospective reasoning. After a comprehensive grasp of engineering has been gained through study and experience, it is not difficult by retrospection to analyze a field of engineering and line up a logical array of separate courses, physics, mathematics, mechanics, thermodynamics, etc., representing the requisite tools and disciplines of this field. Engineering curricula have come into being essentially in this way and have not been planned adequately to account for the natural process by which most students learn best. In addition to a forceful stimulation of interests this natural process of learning calls for ample opportunity to exercise and expand these interests through direct contact with real engineering problems of sufficient breadth to demand for their solution the synthetic use of the separately studied tools and disciplines. To a certain degree progress can be made to foster interest and integration by effective teaching within existing separate courses. But there is a real need for added opportunity in the form of a sufficiently close contact with selected professional engineering situations of appropriate complexity for encouraging the student to make his own selection and use of tools and methods that are suitable. This need for direct and simultaneous use of the several subject matter tools that are being studied is particularly great in the *first two years* of study which is an important formative period. What is needed in curriculum construction and in teaching philosophy is a planned sequence of experiences and an approach to teaching which fully account for the viewpoint and needs of the learner. The learner's viewpoint is one of anticipation and his needs are for activities which represent synthesis as well as analysis but above all are both purposeful and interesting from an engineering point of view.

### V. *Engineering Problems and Projects in the Curriculum*

It may now be stated that effective study in engineering requires (a) the stimulation of interests to produce ample motives, (b) the exercise of motives through doing, and (c) experience in synthesis along with analysis. Thus, effective study is governed largely by intrinsic forces and occurs mainly in the course of doing interesting and purposeful things. Only when these principles are fully recognized are we ready to propose major improvement in our engineering program. The proposal which is offered here to further our approach to these objectives is that we provide ample opportunity during *each* term of the *entire* period of undergraduate study for intimate contact with a variety of real engineering situations that require synthesis as well as analysis. Such opportunity would be in the nature of a separate and continuing course giving interesting professional application to the various separate courses and which might be entitled "engineering projects," "engineering problems," or "professional applications." The course would proceed term by term by bringing the student into direct contact with the demands imposed by real engineering situations, somewhat limited at first but of increasing complexity and with appropriate emphasis directed toward a particular major field as progress in the course of study developed.

The suggestions which follow are offered as indicative of the kind of emphasis advocated. Following an introduction and orientation into the engineering profession as a whole, similar to that now given in most engineering schools, it is suggested that students need some early and direct contact with physical reality in engineer-

ing preferably in the freshman year. Several optional choices can serve for this contact. Surveying, where instrument experience and systematic organization of data are the result, is one such contact. Machine shop, where a feel for the removal and working of metals is acquired is a second example. A course in elementary engineering measurements where such quantities as force, time, temperature, speed, and voltage are measured by the students in conjunction with simple experiments conducted in an engineering atmosphere is a third suggestion. Other possible experiences which would serve to stimulate early interest in engineering among the first year students could be cited.

In the second year of engineering study the student is fully capable of undertaking several simple design projects which follow closely upon his instruction in descriptive geometry, materials, mathematics, and statics. A suitable problem might be the design of a radio station transmission tower. Here the student would be called upon to use the information contained in the subjects mentioned and could further consider some of the associated problems of manufacture, assembly, and cost. The third year student would find that the design of a blower for an air conditioning system, for example, would necessitate his direct use of certain principles of fluid flow, thermodynamics, dynamics, materials, and manufacture. The inclusion of some problems which require knowledge beyond the immediate state of progress of the student can be helpful in pointing out the need for further study. With a background of experiences similar to those suggested here the senior student would be able to handle his design projects with far greater facility than is presently the case. Two or three semester hours of such project work per term would be adequate for the purpose advocated. Before the proposed plan could be put into practice there would be need for much preliminary work by a faculty team to determine the appropriate levels of accomplishment at various stages in each curriculum, the appropriate differences in emphasis for the various fields, the procedure for conducting the course, and to compile a sufficient number of stimulating engineering problem situations.

This suggested plan would offer full opportunity for the encouragement of individual interests upon which true motives depend. When limited to small groups of students individual differences could be accounted for, and originality, initiative, and ingenuity given maximum encouragement. Further, student interests would be stimulated by early contact with activity of a professional character. Also, the opportunity, not sufficiently explored at present, would exist for the student to see immediate practical use for his various tools of engineering. An early demand and challenge would be offered to the student to formulate problems and to select those tools and methods which will yield a satisfactory solution. This type of experience would result in a much needed synthesis and integration of separate courses, methods, and viewpoints. Following closely the instruction in separate fields this problem experience would provide opportunity for a reasonable measure of repetition which must be recognized as characteristic of all learning. Additionally, early experience in dealing successfully with real situations builds individual self-confidence, a quality which far too many of our students currently lack. A further advantage would be the close check on the adequacy of instruction in each of the separate courses as indicated by performance in the project course. Lastly, the results of early contact with professional problems would serve as a valuable indication of suitability for subsequent engineering work and could therefore be used for effective vocational guidance at an early stage. In short, such a continuing problem experience would aid greatly in providing the kind of atmosphere most conducive to engineering study.

This general procedure of using projects in engineering teaching has been re-

ferred to in a number of recent articles in the JOURNAL OF ENGINEERING EDUCATION, three of which are cited here. "The Use of Problems and Instances to Make Education Professional," by B. R. Teare, Jr., vol. 29, no. 3, Nov. 1948, points out by specific example the value of using problems of a professional character in the development of the student. "The Case Method of Teaching on the Senior Level," by J. F. Manildi, vol. 41, no. 10, June 1951, is an excellent description of a comprehensive problem course advocated for seniors where emphasis on the formulation of real problems is given. The recent ASEE committee report "Improvement of Engineering Teaching," vol. 43, no. 1, Sept. 1952, suggests that the "project method" is the most valuable method for developing originality and resourcefulness and advocates its wider adoption primarily within existing courses. In contrast to the messages of these discussions, it is the purpose of the present paper to draw attention to the psychological basis for recognition that this problem or project type of instruction is not only desirable but necessary for the efficient stimulation of learning. Furthermore, it is the purpose here to point out the need for a separately organized and continuing problem course that is offered *simultaneously* with the instruction in separate subjects. It seems to the author that such a plan is preferable to the excessive dilution of individual basic courses which would be the result of inclusion of very many projects or comprehensive problems in these courses.

And now the question of how an additional series of courses can be introduced into an already overcrowded curriculum must be answered. The solution lies in cutting down on the number of separate required courses and particularly the reduction of the excessive proliferation of specialized courses in the senior year. One of our most difficult problems in this age of expanding technology is to maintain an attitude of realism toward the material which can be treated well in four years of study. We must be exceedingly cautious not to promote an excess of superficial knowledge at the expense of true understanding.

### VI. *Conclusion*

Present curricula and teaching in engineering reflect practices of the past that were not appreciably guided by study of the educational process. Responsibility is ours for effecting the most stimulating environment possible for engineering study. This responsibility is particularly great when we observe the increasingly active role which the engineer plays in research and development, in business, and in community, national, and international affairs. Discharge of this responsibility requires a realistic reappraisal of our educational philosophy and demands that we give full attention to stimulating those natural forces which result in optimum performance. We can accomplish this in no better way than to establish early and continuous contact between the student and the challenging problems of the engineering world.


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*"ARTICLE XI, Section 3. (Election of Officers) By means of a form to be printed in The Journal of Engineering Education or in the preliminary program of the annual meeting, an opportunity shall be given to individual members of the Society to submit names of persons to be considered for said officers. These names, on the form provided, shall be sent to the Secretary of the Society not less than sixty (60) days prior to the annual meeting; and the Secretary shall submit the suggested names to all members of the Nominating Committee."*

In order to make the election of officers of the Society as democratic as possible, members are urged to fill out the nomination form and return before April 1, 1954 to the Secretary, A. B. Bronwell, Northwestern University, Evanston, Illinois.

I nominate the following members of the Society for officers:

For President .....

.....

For Vice-President .....
(*In Charge of Instructional Division Activities—two years*)

.....

For Treasurer .....

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Title .....

Institution .....

Date .....

# The Student Develops His Tools*

By PHILIP NUDD

*Professor of Electrical Engineering, Cooper Union*

There is general appreciation of the engineer's work as being creative and productive. Members of our Society have recognized, at least since the 1929 Report on Engineering Education, that the challenge to better teaching is to provide significant student practice in productive and creative work rather than to extend content of factual information. Engineers are well aware that cultivation of an engineering way of approach to a problem, rather than factual information which has been retained, is responsible for their success in new situations.

Teachers are justifiably cautious in placing their faith in new knowledge as being superior to old for the purpose of developing student intellectual power. New engineering tools are welcomed to instruction whenever these tools add power to reason without introducing obscuring complications. New engineering tools and concepts are valuable assets to the learning process if, in addition to strengthening motivation, they are adaptable to student projects. Substitution of content in the curriculum accomplishes little unless the substitution leads to student activity which is realistic preparation for engineering.

Division of the engineering curriculum in terms of subject matter content involves risk that a course will be defined by its informational content rather than by practice afforded the student in developing his productive capacity. Dissatisfaction with the specialized content of some of our courses has led to a proposition that basic science and mathematics should have a larger share of curriculum time. If these subjects are taught in the traditional academic routine there is danger of increasing formalization at the expense of opportunity for teaching engineering. Emphasis on the routine of memorization and testing for retention can fall as short of our objectives as teaching a multiplicity of techniques in the same factual manner in engineering courses.

### *Emphasis on Content*

There has been some resignation to emphasis on content on the grounds that this emphasis is inevitable and productive experience is impractical. It is probably not true that teachers are as addicted to belief in "coverage" of content as their accusers imply. In practice, teachers have had no desire to be negligent in providing productive experience, but there has unquestionably been overindulgence in presenting factual content.

One response to the challenge to provide productive experience has been to introduce a thesis, term paper, course project, or an engineering methods course. These devices are somewhat inconsistent with the principles of learning in that isolated practices do not recognize education as a continuous growth to maturity. An attempt has sometimes been made to correct this defect by inserting the methods course early in the curriculum, or the term paper early in the course, so criticism and experience could guide the student in his later work. A few isolated experiences lead to much the same results as the assumption that students learn written expression only in the English course, and that it is only there that teaching responsibility to develop this ability exists.

* Presented at Chemical Engineering Conference, June 23, 1953.

The principles of learning indicate that a student must experience continuous creative and productive activity on an increasingly higher level to develop his intellectual capacity effectively. Through practice, the tools for reasoning must appear to be an innate part of the individual's character. To merely know of the tools is sufficient for a spectator but not for a creative role.

It is a soundly established principle of learning that lasting values and genuine growth toward maturity of intellectual power only accrue from activity of the learner which is realistically related to his objectives. This principle has directed good teaching toward student centered rather than instructor centered classroom activity. However, we have learned that good teaching, even when student centered, is not enough. Student activity must involve a large proportion of realistic practice in productive work which is significant to engineering.

Students have often obtained more experience in productive work from expression of their reasoning powers in a written report on a phase of contemporary civilization than from an entire science course. Unless student activity involves more than one phase of engineering methods it is intolerably narrow. There should be student activity involving several procedures, such as: interpretation of the problem, collection and coordination of information, consideration of optional methods of solution, and optional recommendations for implementing the solutions. Instruction in anticipation of the problem situation should not rob the student of an opportunity to develop his tools.

It is hardly possible to disagree with the need for student practice in productive work, but we do find wide difference of opinion on the degree to which it is practical to include realistic productive practice in engineering education. The familiar specious arguments are advanced that it is necessary to "give" the student some factual knowledge before he can be placed in a problem situation, or that mathematics cannot be taught by the project method, or that a student can obtain productive experience better in another course. Although projects must be adapted to previous experience and degree of student maturity, they may be devised as readily to introduce the first chapter of the first course as the last. If students or instructors must be won over to this type of instruction, projects need not be ambitious, and they need not be the only method for learning, but there must be sufficient projects in every course for mutual support.

### *Well Designed Project*

A well designed project will send the student to his text or other sources for the information which is to be developed. He will read and evaluate with a purpose and direction consistent with the principles for learning. His rejection of material will develop as important a tool as his acceptance. A combination of existing information and materials will be required in a form which is new and original to the student constructing the product. New tools of the profession may be introduced to provide motivation. When these new tools are introduced projects may be proposed in a form to send the student after elements of the new concept and to make it unnecessary for the instructor to squander the student's time by imparting extensive information on refinements of advanced techniques. If specifications for the project are open-ended, there is opportunity for the student to develop his judgment of relative value and capacity.

Students must be on their own to develop their will and capacity to walk alone. Instructor assistance should be on an individual basis, and should be given only when it is sought by the student. The instructor should then help the student to help himself discover how to work, rather than supply information or solve a detail of the problem situation. Written presentation must be of sufficient length to cause the student to develop his tools for coordination and reasoning. The student's presentation should be reviewed and criti-

cised with at least as much attention to the way he worked and the style of his presentation as to technical details of the problem.

For more than a decade it has been the policy of the Electrical Engineering Department at the Cooper Union to urge instructors to do no lecturing, to hold explanations involving the whole class to a minimum, and to make a maximum number of assignments in a form requiring the student to make a written presentation of considerable length. It has been the objective to involve optional interpretation of the problem, optional methods of solution, and optional recommendations to be derived from the work. Instructors are urged to curb their impulse to provide information in anticipation of the work assignment, or to give assistance before the student has had opportunity to respond to the challenge to extend his intellectual power by developing efficient conditioned reactions through a normal experience of floundering. We have considered our classes to be two- or three-hour work sessions, very similar to the universal practice in freshman engineering drawing. Evaluation is on the basis of work submitted rather than on examinations.

### *Convictions*

From our experience with these teaching methods we have derived several convictions:

1. In spite of all handicaps, this method of instruction is superior to a routine of class discussion, oral explanation, and one-page problems.
2. At least an equal amount of durable information is acquired by the student through this method as compared with methods which emphasize imparting information and testing for retention.
3. The wider the student's experience with this method, and the larger the per cent of his simultaneous experience in it, the more efficient is his development of engineering power.
4. It is possible and important that these methods be a part of all courses from the time the student enters college.
5. The student is troubled by three initial handicaps:
   (1) The student has not had adequate experience in written presentation where coordination and integrity of his arguments were essential to worthwhile conclusion.
   (2) The student has not discovered that a written record is an essential and powerful accompaniment to extended reasoning.
   (3) The overwhelming volume of the student's experience in playing school has conditioned his attitude to the point where he does not expect his education to be a realistic practice for engineering.

We have accepted the concept that final reliance must be placed in the teacher to develop his own teaching procedures, but to make these a significant part of the whole he must not ignore the necessity for coordination with the total program for intellectual growth. There has been some country wide sentiment to the effect that the teaching situation should be altered so instructors would not be able to prevent student self-learning. This may prove to be a desirable solution.

Effective learning should not be obtained at the expense of overburdening the instructor. It should not be assumed that realistic student practice necessarily demands more of the instructor's time than other procedures which are not abused. Initial efforts do require motivation and incentive for the teacher. These can be provided through appreciation from his students, and through recognition of effective teaching as the only important requirement for promotion within the teaching salary scale.

# Aims and Content of Engineering Economy

By ARTHUR LESSER, JR.

*Professor and Head of Industrial Engineering, Stevens Institute of Technology*

Because of the general misunderstanding as to the aims and content of engineering economy, it is pertinent to review the literature on this subject as the first step in this analysis.

Most striking is the concentration of writers on financial mathematics, notably on the concept of compound interest involving long-run comparisons of capital goods investments. Some apparently believe that compound interest formulas and engineering economy are identical. "Engineering Economics and Practice" by Steinberg and Glendenning,[1] a book based on the New York State Professional Engineering Examinations,[2] is exclusively devoted to compound interest comparisons.

Arthur M. Wellington's book on the location of railways [3] is generally accepted as the historical classic in the field of engineering economy. He postulates that railroads were not built for the traffic immediately available upon completion. Plans were generally made for an expanded future traffic which, from available records of completed lines, would presumably increase on a compound interest curve. Thus if a bondholder invested $1 in a railroad, he could expect to earn a compound interest return. Wellington cautioned that it was not safe in making computations to assume compounding of traffic much more than three years in the future—certainly no more than ten years. He recognized that railroad traffic was sensitive to the business cycle. Since he knew that railroads were financed almost entirely by fixed interest securities, he reasoned that the railroad company stockholders, who usually had no actual monetary investment, would lose control because of bankruptcy, if they extrapolated the traffic curve too far into the future. Obviously the heavier the anticipated future traffic, the greater must be the initial investment in physical facilities. This in turn meant higher fixed charges. Wellington further warned that such compound interest rates were "of value only as fixing a maximum which should never be exceeded." [4] He believed that income from railroads, unlike other businesses, could under no conceivable circumstances be destroyed because of the monopolistic nature of the railroad.

In determining the justifiable total investment, Wellington perceived it was important to apply the compound interest concept within the practical limits dictated by the peculiar circumstances surrounding railroad building of his day. When it came to deciding between alternative lengths of line or curvatures in the line, Wellington assumed a perpetual life. Thus he simplified his computations by making it possible to use the capitalized cost method at an assumed or actual rate of interest. Wellington was not troubled by shifting his assumption of a short finite number of years for the total investment to an infinite number of years for portions of the whole. He probably would have justified this shift by saying that the monetary calculation was only a guide for making decisions, and not the most weighty factor. He was careful to point out, particularly to young engineers, the need to weigh every other relevant factor. Wellington was a practicing engineer whose book was a guide for other practicing engineers.

Chronologically the next important book was "Engineering Economics," [5] by Fish of Stanford University, also a man with a

railroad background. His second completely rewritten edition in 1923 has proven more significant than the first edition published in 1915. Therefore I shall discuss only the 1923 edition.

*Business Side of Engineering*

Fish took an entirely different approach which has been substantially followed until this day. He wrote from the standpoint that "the engineer's professional success and contribution to public welfare depend in a great measure on his understanding of the business side of engineering—of engineering economics." [6] As early as 1897 Alexander C. Humphreys, later President of Stevens Institute of Technology, also preached the need for engineers to learn business methods.[7] Humphreys' view of economics of engineering was broad, encompassing what might today be called industrial management. Fish's concept was that engineering economics was a financial matter based on the choice of investment, rather than on the choice of structure, i.e. anything from a building, machine or road to a plant.

When Fish decided the central problem of engineering economics was investment, he looked to the Wall Street bond market for his prototype or model. He envisaged the capitalist as choosing between investments in alternative structures just as the same capitalist would choose between bond investments. By using what I shall hereafter call the bond market analogy or model, Fish transferred the emphasis from the engineering considerations of Wellington to financial considerations. His book is an introduction to the field of investments stemming out of engineering structures rather than security issues.

Fish looked upon the investment in a structure as the purchase of a capital asset. The life income of this asset would pay all costs of operation and amortize the capital cost, leaving a yield or return on the original investment. The annual operating costs and income are to be computed as hypothetical equivalent uniform payments, or, under certain conditions, yearly averages. Depreciation is to be computed on an invested sinking fund basis. Presumably the analogy between investing in a bond and an engineering structure is close.

The bond buyer purchases a set of future expectations. These consist of a specified number of semi-annual coupons of a stated amount which are good on their respective dates, an annuity certain. In addition, the buyer expects the return of the original investment, if purchased at par, at the maturity date of the bond. According to Fish, the potential investor will buy a bond or alternatively a structure, if the qualities of the investment, including yield, compare favorably with an imaginary set of qualities in the investor's mind—qualities that pertain to the least advantageous opportunity he believes acceptable to him. For situations where income is considered equal, yearly costs of alternatives are compared and differential cost is compared with the differential investment to determine yield.

*Bond and Structure Investment*

Fish satisfied himself that there was a close correspondence between the concept of bond investment and structure investment. His book does not analyze the correctness of this deduction. Since he dealt primarily with structures where the future is less difficult to forecast, his analog may be appropriate. On the other hand, experience has shown that his restricted financial approach, which set the pattern for many years for subsequent writers, has been a handicap to the full development of engineering economy. It has led some to assume that engineering economy and the bond market analog are the same. Others have applied bond market model indiscriminately whether the assumptions underlying its applications have been fulfilled or not. Emphasis on the financial side has resulted in many instances either in virtual exclusion of other considerations, including engineering, that are not reducible to dollars. However, it should

be noted that Fish did introduce irreducible factors in his analysis. But these factors were chiefly concerned with financial considerations that would be of interest to the bond market investor and not to the engineer making a decision.

Also in 1923, Goldman's "Financial Engineering" [8] appeared. Goldman, like Fish, felt the second edition of his book was superior to the first edition published in 1920. Goldman said, "there are primarily two divisions to our entire problem, namely, cost segregation and cost analysis, as applied to (a) cost determination and (b) design for best economy." [9] Goldman devoted himself exclusively to investments in long term assets such as motors, engines, pumps and facilities used in power plants. He leaned heavily on compound interest calculations for purposes of comparison. Goldman provided data on operations and costs of equipment. However, he dealt only with financial considerations and not with those factors that could not be reduced to financial terms. Evidently he desired to provide "a definite, scientific method of determining the comparative value of all things which he (the engineer) must use and the value of systems and of investments in general." [10] Goldman completely neglected to mention the limitations of his methodology. One can understand how he might have led his readers to believe that financial engineering was a special kind of engineering where certainty reigned.

I do not believe it was an accident that both Fish and Goldman emphasized financial considerations. They both wrote in a period when the investment markets were pivotal in our economy. In a sense, survival and expansion were based on whether financial help could be obtained from investors through organized markets. Now Wall Street is no longer in a commanding position. Due to internal financing some business enterprises have found it unnecessary to resort to outside investment sources for funds. Thus financial considerations, as exemplified by the investor viewpoint, have substantially given way to production or marketing considerations. As a result we must ask ourselves, "Has thinking in engineering economy kept pace with this fundamental change of conditions?"

Following in Fish's footsteps, Grant published his text in the engineering economy field in 1930.[11] Grant realized that Fish's preoccupation with the concept of engineering economy as synonymous with bond investments was not sufficiently broad. Grant advanced beyond Fish. He introduced comparisons which did not involve long term investment comparisons. He devoted an entire section of his book, Part II, to factors of judgment, enlarging their scope from the irreducibles of Fish which included little more than considerations involving bond investment. He showed the weakness of using capitalized cost comparisons. He indicated that statistical methods would be valuable in engineering economy studies involving sampling. (Two decades later Grant attacked this problem in the second edition of his "Statistical Quality Control." [12]) Grant pointed out in his section on Review Problems that the textbook problem generally oversimplified the technical facts. This gives an inadequate picture of the difficulties encountered by an engineer when confronted with an actual problem of economy. Unfortunately, it became the fashion to feature simplified problems. Thus they became merely exercises in arithmetic, omitting the real challenges in engineering economy work.

### *Interest on Capital*

Grant accepted the bond market model and put most of his emphasis on using it. But he did not give consideration to the model until his second edition appeared in 1938. For example, he indicated that there was real justification in engineering economy for using interest on capital rather than just using it as a convenient means to make comparisons involving time. However, the crucial question is whether the computation method is appropriate under the circumstances. Grant

also proposed that compound interest calculations giving exact comparisons were often unjustified in practice because of the unreliability of estimates. He felt simplified solutions using average interest over the estimated life were often just as good in practice as more time-consuming compound interest computations. However, for theoretical work Grant returned to the bond market model with appropriate modifications. He considered the popular short payoff or capital recovery period as a means of introducing a safety factor, albeit of unknown magnitude.

Rautenstrauch, who as early as 1907 gave a course in Works Management for engineers at Columbia, published "The Economics of Business Enterprise" in 1939.[13] He incorporated the usual engineering economy techniques in his analysis of the economic characteristics of industrial organizations. These characteristics, consisting of the relationship between income and expenses, were revealed by the now familiar break-even analysis which Rautenstrauch introduced. Thus Rautenstrauch stands somewhere between Fish's viewpoint of engineering economy as a problem of investment and Humphrey's viewpoint of engineering economy as encompassing the field of industrial management.

In 1942 two new texts on engineering economy appeared, one by Bullinger[14] and the other by Woods and De Garmo.[15] Both were designed for undergraduate students. The real difference between them and their predecessors was one of emphasis, and, to a certain extent, approach. Bullinger emphasized the importance of intangibles in arriving at a decision. He would settle for the best attainable or optimum results considering all factors. Woods and De Garmo favored the more restricted, least cost criterion using the bond market model.

### *Dynamic Model*

In 1949, Terborgh published his "Dynamic Equipment Policy."[16] Terborgh's primary interest is in replacing industrial equipment, notably machine tools. Hence his methodology is not a general treatment which can be used indiscriminately in any situation.

Terborgh points out that many types of capital goods during their life time do not continue in the service for which they were originally intended but are "kicked downstairs" in the scale of service. He rejects the customary static model of comparing a piece of equipment already performing a certain function with a challenger, a piece of equipment new at the time the analysis is made. He creates a dynamic model wherein he compares the defender with equipment yet unborn. Thus he introduces an estimated amount of obsolescence as compared with the usual guesswork in respect to the obsolescence factor, if it is considered at all. Terborgh's chief interest is in developing a formula so that quantitative monetary comparisons can be made. He is careful to say that results obtained from using his formula are not final but a first approximation with the ultimate decision an act of judgment.[17]

He uses the compound interest method for the recovery of capital in developing his theory. Like Grant, he says that a sufficiently good approximation is available by using simple averages rather than the more exact compound interest computations. He develops his formula accordingly.

Terborgh is particularly critical of the short pay-off requirement as a means of deciding among alternatives. He says the short pay-off period results in the undue prolongation of the life of existing installations by requiring the next year's advantage of the challenger over the defender to be inordinately large. This puts a protective wall around the defender until it is much past its usefulness. In addition, this criterion carries with it implicitly the notion that the only desirable replacement is that which meets the short pay-off period. But there may be many reasons of equal or more validity, such as demands of competition or of safer opera-

tion. Terborgh also takes to task the rate-of-return or yield on investment requirement, a corollary of the short pay-off period. He also criticizes the minimum-average cost formula—the bond market approach.

This book ends with the thought that American industry in appraising replacement needs has had nothing better to work with than folklore and superstition. Terborgh's chief contribution has been in revealing the assumptions and weaknesses of the accepted procedures in the field. However, the alternative he suggests is not the complete answer.

During 1950, the same year when Grant's third edition appeared, Thuesen's "Engineering Economy" was published.[18] Thuesen's major contribution is broadening engineering economy to include the consideration of questions involving manufacturing operations where time is not a variable. In Chapter 15, "Economy of Operations," he takes up the economical size of repair crews, and economic loading of equipment. He also suggests the use of input-output analysis which leads to the idea of optimizing output given certain inputs into the system.

### *Impact of Income Taxes*

Grant in his third edition, turned attention to the impact of income taxes on engineering economy studies, in addition to embodying the material covered in his second edition. And, in Chapter 20, he gives a review and critique of some of Terborgh's ideas.

It is evident that the writers have been most concerned with the techniques of analysis rather than the nature of engineering economy, perhaps because most of the books were designed as texts. But what can be said of these techniques? Are they useful? Are they adequate?

First, they are quantitative. Usually, but not always, they have a saving clause to the effect that the monetary analysis indicates the direction of solution only, and not the final answer since all variables cannot be quantified in monetary terms. We can rationalize this approach with the observation that it is the best that can be done in teaching undergraduate students. However, this explanation is not adequate when considering engineering economy as a discipline or as an important tool for practicing engineers. There is a real need for a technique which will incorporate all relevant variables in each problem.

One approach worth exploring would be to require the student to indicate in each situation what the relevant variables are. Perhaps he can do this with the aid of a check list, even if he cannot evaluate them all. Even more fundamental are problems of broader scope than are generally available at the present.

Second, some of the techniques like the short pay-off period or return on investment, are little more than rules of thumb. Those techniques involving financial mathematics, notably compound interest—the bond market model—are almost entirely academic. It is generally conceded that a large portion of industry, other than the public utilities, does not use compound interest calculations. Many firms in fact do not use interest in their calculations. Is industry wrong or are the academicians wrong in urging this approach?

One answer may be that if industry does not accept the technique there is little justification in giving it more than passing notice. Or alternatively, we may take the position that the technique is inherently sound and deserves the emphasis it gets. However, saying that the technique is sound does not make it so. The time has come for the technique to be evaluated particularly in reference to its verification in practice. If it is found to be a useful and valuable tool in public utilities and public works but not in manufacturing, then it should be so stated. If it is found to be of little use as an analytic tool in any context, this fact should be admitted. In an eminently practical field like engineering economy, theoretical solutions which have little or no semblance to real life have little justification.

The nature of the data used in engineering economy studies is a subsidiary aspect of the techniques themselves. Text book writers in the field agree that the principal data are furnished by accountants. Therefore it follows that, for those who are expected to use engineering economy techniques in practice, only the customary brief look at these fundamental data of engineering economy is not enough. This is especially so now that some companies are using data derived from standard cost studies. The potential role of statistical techniques in engineering economy studies also needs to be looked into more deeply.

*Philosophy of Engineering Economy*

Valuable as techniques are, they are not enough for a discipline. We must also know in what direction the discipline is going to be sure the techniques are the proper tools for the discipline. The literature does not give any crystallization of thought on the nature or philosophy of engineering economy. But portions of it pieced together in broad terms reveal that:

1. The principal objective of engineering economy is to aid in making decisions between alternatives arising out of engineering work.
2. The role of engineering economy is to develop a framework and to create techniques within this framework which techniques will be of practical significance to resolve actual problems.
3. The framework consists of the following major points:
   a. Engineering economy embraces the study of all factors of variables which enter into a choice among engineering alternatives. (Restricting engineering economy analysis to the factor of monetary cost alone presupposes that this factor is the controlling variable.)
   b. Relevant factors or variables should, as far as possible, be expressed in terms of monetary costs and revenues in order to minimize the judgment area for final decision-making in respect to those variables which cannot be expressed in monetary terms. (If all variables could be expressed accurately in monetary terms, the resulting quantitative analysis would indicate immediately the preferable choice.)
   c. Since all relevant factors or variables cannot either be minimized or maximized at the same time the result sought should be an optimum relationship among the variables. (For instance in a public utility, cost of service cannot be minimized at the same time the elements entering into service to customers is maximized.)

Based on this framework, it is not surprising that some texts on engineering economy have included some subjects and not included others. The authors confine themselves to the variables they think should be given most attention within the limitations of a book.

*Proposals*

This is a sound framework. But neither implementation through the techniques nor the techniques themselves are entirely adequate. Therefore, I make the following proposals in broad outline:

1. Studies should be conducted on Engineering Economy as a discipline and on the techniques themselves.

2. A subcommittee of the Engineering Economy Committee should be established, initially for a two year period for these purposes.

3. Through ASEE an effort should be made to obtain financial backing.

If the above suggested program is adopted and carried through vigorously and imaginatively, engineering economy can become a more live, dynamic subject.

REFERENCES

1. M. J. Steinberg and W. Glendenning, "Engineering Economics and Practice," W. Glendenning, Bayside, N. Y., 1947.
2. Cf. Arthur Lesser, Jr., and E. R. Crilly, "New York's Examination in Economics of Engineering and Practice for Licensing of Professional Engineers," *The American Engineer*, January 1950.
3. Arthur M. Wellington, "The Economic Theory of the Location of Railways," John Wiley, New York, 1887.
4. *Ibid.*, p. 85.
5. J. C. L. Fish, "Engineering Economics," Second Edition, McGraw-Hill, New York, 1923.
6. *Ibid.*, p. V.
7. See Alexander C. Humphreys, "Lecture Notes on Some of the Business Features of Engineering Practice," Stevens Institute of Technology, 1905.
8. O. B. Goldman, "Financial Engineering," John Wiley, New York, 1920.
9. *Ibid.*, revised edition, p. 6.
10. *Ibid.*, p. V.
11. E. L. Grant, "Principles of Engineering Economy," Ronald Press, New York, 1930.
12. See E. L. Grant, "Statistical Quality Control," Second Edition, McGraw-Hill, 1952, Chapter XVII.
13. Walter Rautenstrauch, "The Economics of Business Enterprise," John Wiley, New York, 1939. Also see the successor volume—Walter Rautenstrauch and Raymond Villers, "The Economics of Industrial Management," Funk & Wagnalls Co., New York, 1949.
14. Clarence E. Bullinger, "Engineering Economic Analysis," McGraw-Hill, New York, 1942. A second edition appeared in 1950.
15. Baldwin M. Woods and E. Paul De Garmo, "Introduction to Engineering Economy," Macmillan, New York, 1942. A second edition is scheduled to appear in 1953.
16. George Terborgh, "Dynamic Equipment Policy," McGraw-Hill, New York, 1949.
17. *Ibid.*, p. 134.
18. H. G. Thuesen, "Engineering Economy," Prentice Hall, New York, 1950.

# College Notes

The **Pan-American Federation of Engineering Associations** (UPADI) will hold its Third Convention in Sao Paulo, Brazil, August 3 to 13, 1954. The time was selected so that engineers might attend both the UPADI Convention and the World Power Conference. Anyone interested in learning more about UPADI or the Sao Paulo Convention may secure information by writing to UPADI, Box 40, Midtown Station, New York 18, N. Y.

* * *

Program plans for the 1954 annual short course in corrosion held by the National Association of Corrosion Engineers are well under way, according to Dr. M. F. Adams, N.A.C.E. program chairman and associate chemist, Division of Industrial Research, **Washington State College.** The five-day course to be held on campus of Washington State College at Pullman, February 1–5, 1954, will present a brief but intensive review of the fundamental aspects of corrosion followed by panel discussions and lectures on the applications of corrosion control in industry. The Division of Industrial Services of the Washington State Institute of Technology is the college sponsor of the course.

The program includes five general topics—fundamentals, practical aspects, corrosion mitigation, materials of construction, and environment.

For further information address requests to Professor E. B. Parker, Director, Division of Industrial Services, State College of Washington, Pullman, Washington.

# Should Residence Credit Requirements be Retained?*

BY GEORGE B. HOADLEY

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In recent years, much pressure has come upon engineering graduate schools to make graduate training available to the employees of industry as an out-of-hours program. In the large industrial centers this demand has been met by late afternoon or evening courses. In fact, some institutions such as the Polytechnic Institute of Brooklyn have based their reputation in a significant measure on highly successful programs of this sort. But in some situations, evening courses are not enough to meet the demand. Industries and government installations located some distance from college campuses see advantages to them in proposals to bring the professor to the students by having courses taught at the plant or laboratory rather than on the college campus. The distances involved may range as high as 100 miles, so travel time and cost become significant factors. Such proposals can usually meet the existing college regulations regarding degrees in all but one respect, the residence credit requirement. To the enthusiastic supporter of an off-campus study plan, this requirement seems like a "gimmick"—a requirement with little real significance used by the authorities to block progress, and put in the regulations originally because some other more prominent school had such a requirement.

On the other hand, the proponent of the classical full treatment for graduate students views the residence requirement as being a protective bulwark against unwise proposals, fully justifiable in terms of the academic experience it insures to the student beyond the formal attendance at classes. The gulf between these two viewpoints is indeed wide, and when different groups in the same college espouse these different views, it becomes imperative that each should study carefully the viewpoint of the other before final decisions are reached regarding off-campus work. I shall try here to explain briefly several viewpoints regarding residence credit without going into any of the other aspects of the off-campus course problem which may be really serious to an administrator but which do not concern the student.

### *Equivalent Facilities*

The first value claimed for the residence requirement is that it makes the facilities of the college available to all students. Usually such items as classrooms, laboratory equipment and library resources head the list of facilities. However, the doctrine of "equivalent facilities" soon arises, and the college may well find itself embarrassed by the unfavorable comparison between its own facilities and those offered by the organization requesting the off-campus work. For example, I have taught in college classrooms where half of the seats in the room were unusable because of glare from the blackboard.

Of course the college should assure itself that satisfactory facilities are available if off-campus courses are offered. But there should be no middle ground

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where facilities are not good enough to give full credit for a degree but yet are good enough to allow a course to be given. If such is done, it is an admission of a venture into substandard work.

One other point regarding laboratory and library facilities is worthy of mention. There is a vast difference in the requirements between courses. Some courses require no laboratory at all, and the library requirements vary from course to course, so the adequacy of facilities must be determined individually for each course.

Other matters which must come in for discussion are the quality and level of the work, and the teaching ability of the person giving the course. All of these factors must receive careful attention before an off-campus graduate course is offered, but once it has been determined that the course will be truly of graduate calibre, it should be fully accepted as such.

The program comprising such courses will be restricted to the courses offered, so may not be as well suited to the particular preference of each individual as would be the case in an on-campus program, but it will meet the interest and needs of most of the off-campus students. Thesis requirements for the degree can be met by a project carried out under the supervision of a faculty member at either the off-campus location or at the college. Different colleges have diametrically opposite views on this point. Either method can be made to work effectively.

At this point in our thinking we have reached the view that if a course is of graduate calibre, it matters little where it is taught, so that on this basis the residence credit requirement has no meaning except to insure that an adequate proportion of work is taken under the auspices of the college granting the degree. If no other ideas are involved, residence credit is an unjustifiable requirement and should not be retained.

### *Broader Concept*

There is, however, a broader concept of graduate training which has been most excellently stated by Dean Hazen and his associates in the M.I.T. Graduate School Manual, issued January 1953. I recommend this pamphlet to all of you who are concerned with the problems of graduate education. The essence of this viewpoint is that true graduate study is an educational experience in a community of scholars without the distraction of a job being held at the same time. This experience requires the undivided attention of the student to the problems of study and research, with ample opportunity for real association with "able men under the stimulus of intellectual competition with associates."

Such a concept of the residence requirement does not completely eliminate off-campus work since some non-college research laboratories do maintain the intellectual atmosphere in their daily work. At such locations, off-campus work could be approved, but most development laboratories and industrial plants would be excluded.

### *Two Types of Degrees*

There is a real need in America today to bring additional study to people in industry. In agriculture this has been done via the extension worker, and the college authorities proudly proclaim that the college campus covers the whole state. In engineering we are in a different situation because the people we wish to reach in this effort are already college graduates and to them the possibility of another degree is part of the incentive for advanced study. Therefore, I propose that two types of graduate degrees be generally accepted throughout the United States. The first of these is the Master of Science, a degree awarded only to those who experience the full educational experience of undistracted association with intellectual peers in an atmosphere of academic quality. The second of these is the Master of Engineering, a degree awarded to those who complete a satisfactory program of advanced technical work and who show evidence of ability to take the initiative

in the solution of a technical problem, such as a thesis problem.

If we can generally agree on these two types of degrees, we retain the strict residence requirement for the first and dispense with it for the second. This gives a framework for each type of operation, and the prospective graduate student can select his school and his program to suit his desires. But here we need a directive to catalog writers. If residence credit is required, its justification should be explained to the prospective student so that he can really understand the difference between a program with such a requirement and one without it.

# Present Status of the Japanese Society for Engineering Education

By KINJI SHIMIZU

*Managing Director of JSEE*
*President, Nagoya Institute of Technology*

The American-Japanese Conference of the Institute for Engineering Education held in the summer of 1951 was a great impetus for the improvement of the Japanese Engineering Education. As the result of discussions at the meetings extending 2 months, Japanese engineering teachers and industrial representatives decided to organize a Society for Engineering Education in Japan, such as ASEE in America.

Japanese engineering education having about 60 years' experience had no organization where improvement or development of the education should be discussed or engineering teachers should criticize their teaching with each other. The aim of the society we were to organize was to discuss freely the ways for improving and developing engineering education on the one hand and to realize, on the other, the cooperation of engineering teachers and industrial engineers for its promotion.

Dr. Shimizu spent considerable time in America gathering ideas concerning engineering education, including three months at the Technological Institute of Northwestern University.

After several meetings from November 1951 to March 1952, held by nation-wide representatives, it was decided that seven regional societies—Hokkido (Sapporo center), Tohoku (Sendai center), Kanto (Tokyo center), Tokai (Nagoya center), Hokuriku (Kanazawa center), Kansai (Kyoto and Osaka center), Kyushu (Fukuoka center)—be established at first and then their federation, the Japanese Society for Engineering Education be organized.

By the middle of July, all 7 regional societies started and we held the inauguration ceremony of JSEE on August 7 at the Japanese Engineer's Club, Tokyo. Miss Snavely of the Unitarian Service Committee, attending the ceremony, read the message of Dr. H. L. Hazen, the chairman of the American Advisory Mission to Japan for Engineering Education 1951, and that of President W. R. Woolrich of ASEE, both of which made deep impressions on the audience. JSEE issued its first publication in April this year, entitled "Engineering Education," and held its first annual meeting in Tokyo at the Engineer's Club July 9–10.

# A Study of Teaching Methods in Engineering*

By W. R. LEPAGE, *Professor*
and
R. P. LETT, *Assistant Professor*
*Electrical Engineering Department, Syracuse University*

For many years it has been common practice in college teaching of so-called lecture and recitation courses to assume that if the teacher was familiar with the subject matter it was only necessary for him to "present" the material to the class, after which the student would obligingly learn the subject and everyone would be happy. Unfortunately, it seems to work this way for only a very small percentage of the students of an average class. Realization of this fact on the part of some members of the E.E. staff at Syracuse University has led to a series of experimentally conducted courses. Of course, no panacea could be expected, but a series of procedures have been tried which finally lead up to a technique which, it is believed, shows promise of being superior to the traditional methods.

To begin with, it is important to state what we believe should be the objectives in a teaching relationship. Accordingly, the following objectives were considered important for the experiments under study. The student should:

1. Acquire a knowledge of the facts, terminology, conventions, and methodology of the subject matter of the course.
2. Acquire a comprehension of the fundamental principles of the course and an ability to apply, interpret and extrapolate these principles.
3. Develop an ability to analyze and synthesize situations involving these principles.
4. Develop self reliance so that further study in this field and in related fields, by the student alone, will be possible.
5. Develop an ability to evaluate and exercise reliable judgments in the course area and related fields as well as some grasp of self-evaluation.

In reviewing the possibilities for varying teaching techniques it is fruitful to give thought to certain psychological effects which may be overlooked in the usual classroom situation. It is felt that the following factors should be given more attention in teaching methods than is usually the case.

1. The student should be at ease in the classroom situation.
2. The student should be made to feel that the teacher is his friend and helper, and therefore his employee, rather than in competition with him.
3. Emphasis on grades should be minimized, so that the student will feel that his purpose is to gain insight and understanding rather than a label of a certain degree of "accomplishment" in the records office.
4. It should be realized that a student really learns only those things he wants to know, and is not particularly influenced by what the teacher thinks he should be interested in. In psychological parlance this is to say that the teacher can communicate with the student only if there is

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considerable overlap of the "phenomenological" fields of the two individuals.†

5. Closely allied with point 4, the classroom should be a place of real learning, rather than a place of "entertainment."

6. The student should *not* look to the teacher as an absolute authority.

In view of these considerations, with the help of members of the Education Department of Syracuse University ‡ an experimental teaching program was set up in a beginning course in A–C Circuits. This experiment is reported upon elsewhere,§ and so the report given herewith continues after the termination of experiment 1. Suffice it to say that the first experiment utilized the so-called nondirective approach, leaving the student wide leeway to learn by himself.

### *Some Difficulties*

Some difficulties were experienced with that method. In particular, there was no adequate way to arrive at a grade at the end of the term, and with the pressure of other courses some students tended to neglect the non-directively taught course. Therefore, although the non-directive method did show good results in some respects, in view of the need for grades, and the competition with other courses, other less radical techniques were tried. The present paper consists of an outline of three successive experiments, following experiment 1, with results such as they are known to us. Whereas experiment 1 was conducted with a control group, experiment 2, 3, and 4 had no controls, and so evaluation of results is less objective than would be desired.

### *Experiment 2* (Student-centered A)

This is called a student-centered method rather than non-directive, because attention was directed at helping the student to feel that the class belonged to him, while the teacher actually assumed quite a bit of direction over the work. The following quotation from the instructions given to the students indicates the essence of this experimental method.

All of the material needed for an understanding of the subject is the text. Therefore, there is no need to have the instructor lecture on the subject matter that can be acquired by reading. The student is largely on his own to get his first contact with the material, from the text. The class period will serve as a discussion time, and as a period for working problems. Most of the discussion may arise out of the exercise problems. There will be no essential difference in the manner of conducting the "problem session" and the "recitation session." They are both to be considered as combined problem-working and discussion meetings.

Discussion among small groups of students is to be encouraged. Different students will progress at different rates, and so there may be various discussions going on simultaneously. It is hoped that a complete atmosphere of informality can be attained.

### *Teacher is Consultant*

The purpose of the exercise problems is to gain an understanding of the principles they illustrate. They are not to be worked merely for the purpose of having them checked off in the instructor's record book. For this reason, problems will not be collected and graded. The teacher's only role is as a consultant.

Quizzes are to be regarded as measuring scales, to determine your attainment, rather than as final irrevocable evaluations. If the results of a quiz show that you do not have a certain minimum of understanding, you will be given another chance, without penalty. That is, the quiz grade will not be recorded, unless it is above a certain minimum. Although the instructor's role is that of helper and consultant, he retains the role of judge, to the extent of deciding whether the attainment of each student meets the minimum standard. If a student does not meet the minimum requirements, as judged by the instructor, another quiz can be given, after the instructor is satisfied that more

† Snygg and Combs, "Individual Behavior" Harper Bros. 1949.

‡ Particularly Dr. K. N. Peterson.

§ To be arranged.

studying has been done after the unsuccessful attempt. He may require proof of additional work having been done, if he deems it necessary. Furthermore, he reserves the right to refuse to give additional quizzes, if he feels that the student is not making an effort. If this is done, it is not in a punitive sense, but to protect himself against the contingency that a student may attempt to take quizzes repeatedly, without studying, in the hope that eventually he will "hit" one he can do.

It is suggested that the class members make out the quizzes, using the problem book, and the question sheets, as a guide. The appropriate number of quizzes required to cover the work can be decided by the class. Two or three students can make out each quiz, with the aid of the instructor. This job can be passed around the class as the term progresses. In any event, the members of the class should feel that in reality it is the class as a group which is testing the individual members of the class, and employing the instructor to help them in the process.

It will be noted that the method of quizzing is one of the unique features of this experiment. It was hoped that the method would develop a sane attitude toward grades, while at the same time being more effective than usual methods of weeding out students who do inadequate work. With the usual method of quizzing, a student who fails to pass a quiz is normally allowed to continue, always with hope in his heart that somehow he will do better the next time; while the chances of his doing better quickly fade as he fails quiz after quiz. With the procedure of experiment 2 an inadequate student merely fails to complete the course. That is, he may spend a whole term on only half of the work; but the important thing to note is that he is not allowed to go unprepared into new work, because no quiz may be taken if the previous one has not been passed with a certain minimum standard.

The method did accomplish the above objective to some extent. In fact, one of the desirable features was that it caused a few students to drop the course early in the term, when they saw that they had no hope of success. The number of quizzes became too great, however, to continue student authorship.

### *Make-up Quizzes*

Probably the greatest drawback to the method was the need for a large number of make-up quizzes, and that there was no pacing of the course by the instructor. In many instances instructors had to make up individual quizzes for single students, because a quiz was given "on request" whenever a student claimed to be ready for it. The result was that some students did the second half of the course in the last two weeks of the term. Also the students felt that class time was not used efficiently, as shown on an unsigned student questionnaire. (See Chart 1.)

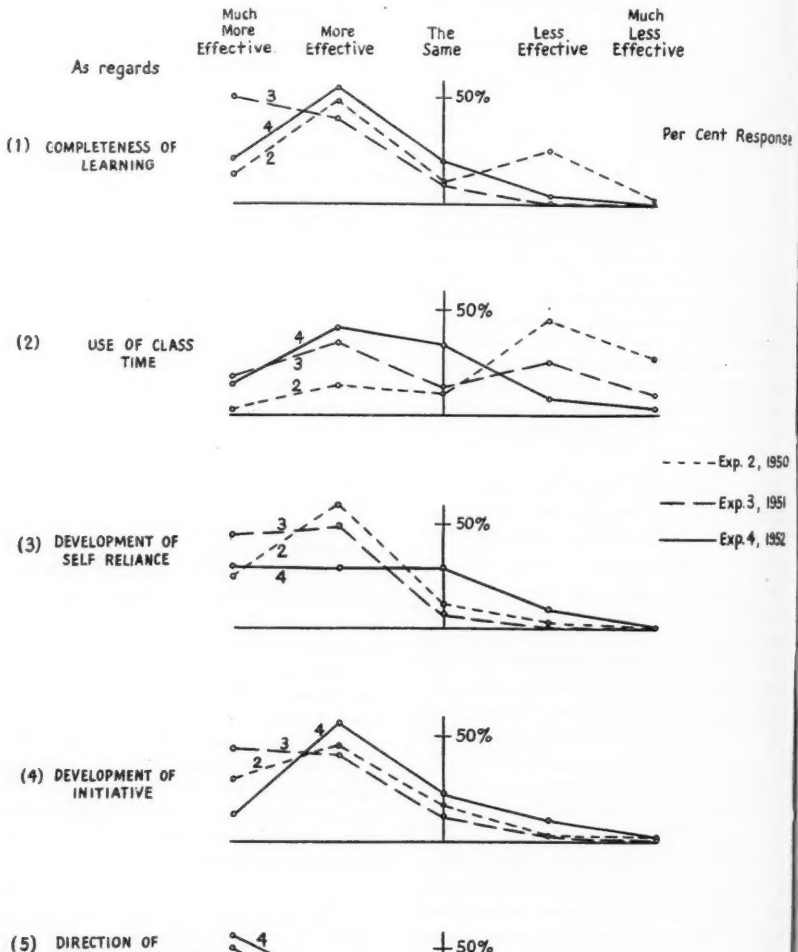
### *Experiment 3* (Student-centered B)

The next method tried was an attempt to remove one difficulty of experiment 2; namely, the difficulty that the class did not pace itself properly. Accordingly, this function was given to the faculty, but not to the student's teacher. The pacing function was not given to the teacher in order to avoid as much as possible returning to a state of competition between student and teacher. Class room procedure otherwise remained about the same as in experiment 2, as was explained to the class at the beginning of the term in an instruction much like the one quoted for experiment 2. Excerpts of the instructions for experiment 3, pertaining to the quiz procedure, are given below.

Your instructor, as an individual, will not give you a grade. His only function, in relation to you as a person, is to help you learn. However, since we must produce grades for the office record, your grade will be determined by the course teaching *staff*, acting as a group. The teaching staff consists of the course coordinator, who does not teach a section, and the section instructor. To see how the quiz and grading system will work, read the following description.

CHART 1

Compared with *other* courses, this course was:



The term will be divided into quarters. At the end of each of the first three quarters a quiz will be given, and then there will be an examination at the end of the fourth quarter. These quizzes, and the examination, will be called the GRADED QUIZZES. They will be made up by the course coordinator and graded by the staff, cooperatively. Your instructor will not participate in making up the graded quizzes, but he will have veto power over any question he may consider unreasonable. Your grade in the course will be determined from the results of the four graded quizzes, *with the one modification explained below.*

Your instructor will make sure you learn a minimum acceptable amount before allowing you to take one of the graded quizzes. In order to do this he will make up and give his own quizzes, which will be called PRELIMINARY QUIZZES. These quizzes will test you for minimum standards. There will be several preliminary quizzes between two successive graded quizzes, and the preliminary quizzes will come in sequence. You must pass each of them in its proper sequence in order to be admitted to the next graded quiz. The preliminary quizzes will be graded as either "satisfactory" or "unsatisfactory." A failure in a preliminary quiz may be made up without penalty. These quizzes are merely measuring gauges against which you test your progress, and a failure indicates there hasn't been enough progress. More study is then needed. In some instances a preliminary quiz may be an informal oral quiz, or it may be waived at the discretion of the instructor, if he feels that observation of class work has provided adequate proof of progress. There will be no waiving of these quizzes for the entire class, only for individual students.

### *Typical Example*

To consider a typical example, suppose the first quarter of the work covers chapters 1, 2, and 3 of the book. Your instructor may elect to give a preliminary quiz on each chapter. You must obtain a grade of "satisfactory" for the quiz on chapter 1 before you may take a quiz on chapter 2, and so on. Finally, you must have passed preliminary quizzes on all three chapters before you may take the graded quiz on the first block of work.

You will note that by the time you have earned the right to take the graded quiz you have met minimum standards by passing the preliminary quizzes. It is therefore reasonable to say that you have attained a grade of C in that part of the work covered by those preliminary quizzes. Therefore, if you are satisfied with a grade of C you need not take the graded quiz at all, or you may elect to take it in order to demonstrate your attainment beyond the C level. In the event that you obtain a grade of less than C in the graded quiz, that grade will be disregarded and you will be given a C on the basis of your preliminary quizzes.

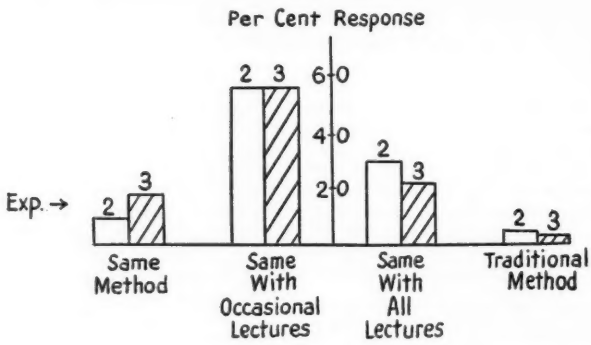
The graded quizzes will be given on a regular schedule, in order to ensure the maintenance of a reasonable schedule or progress. You may therefore wonder what will be done if you should not complete the necessary series of preliminary quizzes by the time of the graded quiz. You will be given every opportunity to meet this deadline; that is, your instructor will cooperate in giving you the necessary preliminary quizzes repeatedly, as long as he is convinced that you are working. However, suppose you still don't meet the deadline and are not admitted to the graded quiz. Of course, if you have a legitimate excuse, you will be given a make up. Lacking an excuse, you will still be given a make up, when you are ready, but the grade attained will be multiplied by the factor 0.7. Furthermore, you will not be entitled to the C grade for having completed the preliminary quizzes, because they were not completed on time.

A failure to meet a graded quiz deadline, without excuse, should be regarded as a serious situation. Should this happen, every effort should be made to close up the gap without delay. However, no time limit is placed on the make up, except that preliminary quizzes in the next quarter will not be given to a student who has not completed the previous quarter. Thus the deficiency of not meeting a deadline of a graded quiz can rapidly become cumulative and lead to failure in the course. Thus, failure in a course taught on this plan will be by not completing the work, rather than by failing graded examinations. We hope there will be no failures.

### *Student Response Favorable*

Student response to this method of teaching was quite favorable, as is brought

CHART 2




out in the subsequent tabulation of the results of student questionnaires. (See Chart 1.) The experiment was tried in two different courses; in an electronic course for EE majors, and the other the first semester of an electrical "service course" for non-electrical students. It appears that the greatest success was scored in the latter course, which was significant because students in past years had shown much apathy toward this course. A fine degree of student cooperation was attained, and there is reason to believe the students learned more than in any of the previous courses taught by other methods. However, the teaching staff was seriously overworked, both in giving help in out-of-class hours, and especially in making out preliminary quizzes and make-ups. In this connection, it is interesting to note a very pronounced tendency for the students to skip the first preliminary quiz, in order to see what it was like, the better to prepare for the make-up. This increased the quiz-making burden beyond what had been anticipated. The making of quizzes was particularly difficult because of the desire to include some new material in each successive make up quiz.

Students reaction to this method, as obtained from the same questionnaire, is also indicated in Chart 1. During the term, many favorable verbal reactions came in, and several favorable comments were appended to the questionnaires. In addition, the students were asked to choose between four methods of conducting courses, varying from this experiment to the traditional system. The results are shown in Chart 2, which shows the students overwhelmingly rejected the traditional approach.

*Experiment 4*

The excessive demands on instructor time of experiment 3 may have been due to student unfamiliarity with these methods and long established student dependence on "spoon-feeding." After a semester, it was felt that the method could be tightened up and the following changes were instituted as indicated by the following quotation from the instructions given to the students.

a) Only one "Preliminary" quiz and one make-up quiz on each section of the work will be scheduled, and no student will be permitted to take the make up unless he has first taken the preliminary. (The usual rules on absence from quizzes will be followed.)

b) A student may elect to skip one or more preliminary quizzes, but in this case he is now required to take the "graded" quiz and the grade he gets on it. If one or more preliminary quizzes are skipped the "C" guarantee lapses.

Two other departures from previous procedure were also instituted. Due to the

wide scope of the survey material a partial return to the lecture technique occurred. The instructor lectured.

a) When the text in his opinion did not meet the course requirements
b) When new concepts caused difficulties
c) When members of the class requested information on a certain topic.

The amount of lecturing varied among the four sections, but probably averaged one half to two thirds of the class periods. The remaining periods were devoted to problem work and discussion groups. The other innovation was to permit a student to write a report on some phase of the application of Electrical Engineering in his own field. The grade on this report was substituted for the lowest of the student's grades on the graded quizzes. This had been tried the previous year and the high quality of most of the reports and the increased interest in the survey course had indicated that this project was educationally valuable.

*Reactions Favorable*

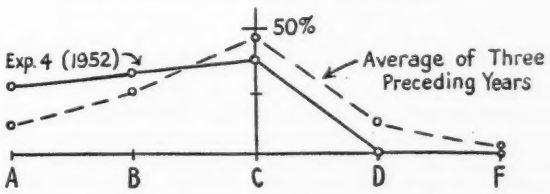
Students reacted favorably to this method. Not more than two or three students (out of the four sections of 20 each) were content to "coast" for a C grade. The grades given were higher on the average than those of previous years as shown in Chart 3, and the class average on the rather comprehensive final exam was not significantly different although slightly higher than the average of the three previous years on an entirely comparable exam.

Two student questionnaires were given at the end of experiment 4. One of these was essentially the same questionnaire used with experiments 2 and 3. As indicated by the summary in Chart 1, the students felt that experiment 4 was preferable to the previous experiments, and much more preferable to other methods of teaching as regards completeness of learning, use of class time, development of initiative and interest, and the direction of attention toward learning rather than grades. The release of exam tension was mentioned as an important factor.

A second questionnaire, which was the student opinionnaire, developed by the Evaluation Service Center of Syracuse University, was given at the end of experiment 4. This opinionnaire has been refined over the past seven years and sufficient norms have been developed so that a good indication of student reaction to

CHART 3

Grade Distribution of EE 46 in Per Cent




Final Exam Average EE 46

1952 (Experiment 4) . . . . . 65.6%

Average of Three Preceding Years . . . 62.2%

teaching procedures can be obtained. This opinionnaire is not designed to judge the effectiveness of teachers and teaching but has been used successfully to help instructors, who are the only ones to see the results. This opinionnaire covers five general areas as follows:

1. Instructional materials and objectives
2. Instructional procedure
3. Tests, exams and quizzes
4. Value of the course to the student
5. Instructor-student relations

The group under consideration scored very significantly higher in all areas as compared with the norms set up over several years on several thousand students, but the most outstanding difference was in the last area, instructor-student relations. In this area the student responses were unbelievably high, part of which may be due to the enthusiasm and cooperation of the young instructors who were teaching this course. Incidentally, extensive checks over several years have shown neglible correlation between the answers on this opinionnaire and the students' grades or expected grades.

*Recapitulation*

It seems obvious to the authors that after much trial and error there has been evolved a more successful method of teaching. While by no means the final word on the subject, the objectives stated at the beginning of this paper have been attained to a considerable extent. There has been enough follow-up of students in later courses to justify a good deal of optimism. Chart 1 is particularly interesting, especially groups 1, 2, and 5, which show not only that the objectives were being obtained but that the students were able to detect the improvement as the methods were refined.

Of course there were many other variables. One of the most important of these was the fact that the student was exposed to this one "student-centered" course at the same time he was taking perhaps four others which were given in a traditional manner. Under the pressure of an engineering curriculum it is easy for the student to slight courses which do not require daily work turned in, and these methods might show to better advantage if they were more universally employed. Another factor which may have been beneficial, was the youth and willingness of the instructional staff, who, having no fixed pedagogical habits, adapted themselves enthusiastically to these experiments. In conclusion the authors can only say they feel that if these methods were instituted earlier in the students' educational career that they might well constitute one answer to the increased amount of material now required in engineering curricula.


## Review of Current Research Available . . .

**You can now get your copy of the "Review of Current Research and Directory of Member Institutions," published by the ECRC, which is just off the press. This is a complete directory of research projects in engineering colleges throughout the country. For a copy write to Professor Virgil Neilly at Pennsylvania State College, State College, Pa. The price is $2.50.**

# Methods of Testing Student Proficiency in the Basic Use of Surveying Instruments

By COL. M. S. DICKSON

*Associate Professor, Department of Military Topography and Graphics, United States Military Academy, West Point, N. Y.*

Surveying has been part of the West Point curriculum from its inception in 1802. In his diary, Jonathan Williams, the first Superintendent of the Academy, describes his leading the cadets in and around West Point for the purpose of making surveys. In addition to familiarizing the cadets with surveying instruments and practices, these surveys were for many years used as the official community land records.

For the first quarter century of West Point's history, surveying and mapping were limited to establishing boundary lines for land ownership. In the 1820's, our young energetic Nation, eager to explore and exploit the rich lands to the West, realized a serious need for engineers, especially surveyors. Therefore, West Point's curriculum was pointed towards engineering in an endeavor to fill this need. Early American history reveals many West Pointers assigned to the Topographic Engineers, U. S. Army, leading the way in exploring, surveying, and mapping the Great Northwest Territory.

Cadets at West Point are required to take, in general, identical academic courses. The Academy curriculum is two-thirds technical-scientific and one-third humanities. There are no electives within the technical-scientific curriculum. Each cadet is required to complete each engineering subject. The curriculum is designed to provide a broad general engineering background to give each graduate a solid foundation for a lifetime of growth in the military service regardless of branch or assignment.

Since all cadets must take surveying, an average class of approximately 600 reports to the Department of Military Topography and Graphics for surveying instruction each September. Surveying is given during the Fall to take advantage of the good weather for outdoor exercises. Subject matter is similar to that in elementary surveying courses given by many engineering schools to general engineering students. Instruction throughout emphasizes the many military applications of Surveying. It is useless for me to enumerate to you gentlemen the many applications. The course consists of approximately 52 two-hour periods of instruction. Since the course is considered a subcourse of Military Topography, the mapping applications of surveying are stressed.

Early lessons of the course comprise a classroom study of theoretical surveying. At present we are using the text "Elementary Surveying" by Professor Warren C. Taylor, Union College. Upon completion of the theoretical work, cadets are given field instruction in the use of the basic instruments—level, transit, plane table, and alidade. This instruction is not designed to produce surveyors, but rather to teach the principles of operation and the capabilities of each instrument. Instruction resembles field work given by most universities, i.e., dividing the class into field parties to solve practical problems with each instrument as time permits. In each class of 600 cadets, we always find a great range in surveying aptitude. Some cadets have the facility and the desire to excel in the course, while others strive only for a

passing grade. I imagine many of you here have experienced similar problems. At West Point, those who excel are called "Engineers," while the lesser lights are dubbed "Goats."

*Deplored Situation*

For years instructors have deplored the following situation. As soon as a party starts work on an outdoor problem, the most apt member of the party operates the instrument, while the goat holds the rod. Instructors continually stress that duties should be rotated, giving each member equal experience. The rotation method usually operates satisfactorily, until a graded problem is assigned. Since all members of the party must necessarily receive the same grade, you can well imagine the anguish of the Engineer (Phi Beta Kappa prospect) standing across the field, holding a rod, patiently watching his grade develop or disintegrate through the efforts of his Goat party-mate attempting to read, record and compute. To eliminate this objectionable situation, the Department ruled that field exercises would be ungraded instruction, taking full advantage of the coach and pupil method to increase facility with an understanding of the instruments throughout the class. At the completion of field instruction, cadets are graded from results of examinations requiring every cadet to individually operate each basic instrument. While discussing the course with a few of the members of this Society, several expressed interest in how we conducted individual performance tests on each of the surveying instruments for six hundred cadets within our limited instruction time. The remainder of this paper is a description of our individual instrument performance tests.

Due to the limited time available for the performance exam, requirements cover only the basic essentials of instrument operation. The three graded exercises require the cadets to:

a. Transit—Properly set up the instrument over a designated point, measure several horizontal and vertical angles, compute horizontal and vertical distance by use of stadia, and properly record the observations.

b. Plane Table and Alidade—Properly set up and orient the table, plot accurately the horizontal location of several points, and compute and record the elevation of the plotted points.

c. Level—Properly set up the level, carry a line of levels through a three-station set-up, and properly record the observations.

The performance tests are conducted in the Military Academy Field House, because the schedule requires that they be given in December, near the completion of the Surveying course, when outdoor weather is extremely uncertain. Since the cadet's grade and relative order of merit for the Surveying course is dependent upon the results of the performance examinations, it is obvious that tests for all cadets must be conducted under equal working conditions. Spotlights are used to adequately light rods not properly readable under Field House lighting. Tests on all three instruments are run simultaneously to obtain the most efficient use of both instruction time and available instruments. All rods used during the exercises are either fastened to the Field House walls or are set up in holders to eliminate the need for rodmen. Elimination of rodmen allows each cadet to use one hundred per cent of his available time in reading and operating the instruments and recording results. In each case rods are adjustable to allow frequent changes in results.

*Performance Tests*

Performance tests are conducted as follows:

a. Transit—Two circles approximately 150′ in diameter are laid out in one end of the Field House with instrument stations as required at about 10′ intervals placed on the circumference of the circles. Three rods, labeled A, B, and C, are placed on each circle directly opposite

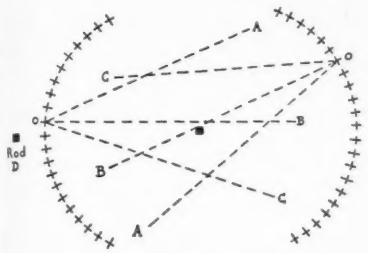



FIG. 1.

each group of instrument stations. The two circles and two sets of rods—A, B, and C—are necessary to accommodate the large number of cadets taking the exam simultaneously. A four-faced stadia rod is placed near the center of the overlap area of the two circles. Two stadia rods, labeled E and D, are fastened to the walls of the Field House at elevations higher than the instrument stations. The transit exercise layout is shown in Figure 1. At the start of the problem, cadets are given the elevation of the base of the four-sided stadia rod. They are then required to properly set up the transit over their assigned station, then to measure accurately the values of the angles AOB, BOC, and COA, and finally to compute the elevations of the rods D and E by stadia methods.

Although not obvious to the cadets, the use of the circular layout results in all stations on each circle having identical correct solutions. This enables one instructor to control, correct, and grade promptly the large number of cadets under his jurisdiction. Upon completion of a group examination, instructors move

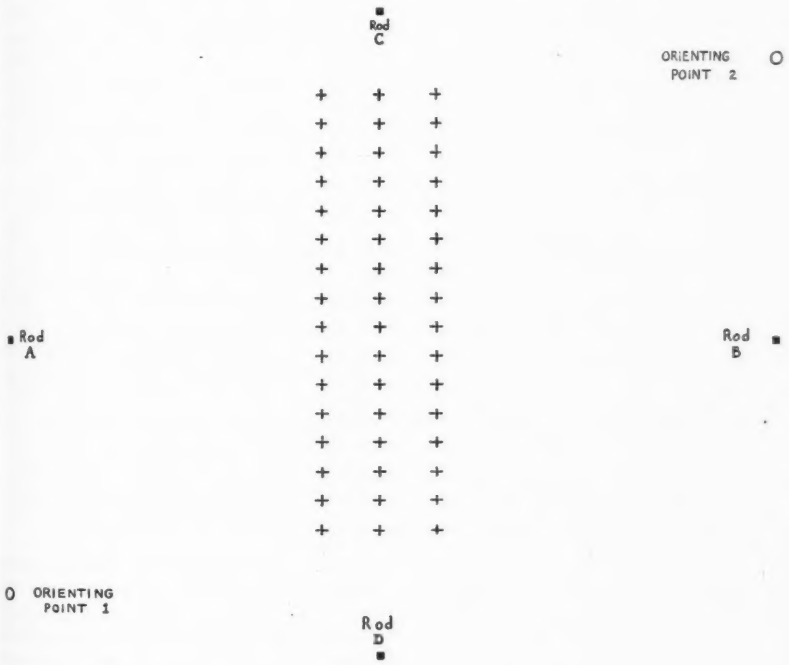



FIG. 2.

the rods and vary the solutions for the succeeding group.

b. Plane Table—Predetermined station points are referenced in and marked on the central portion of the floor of the Field House. The plane table layout is shown in Figure 2. A plotting sheet with all table stations located is given to each cadet. In addition, two orientation points are located on the issued plane table sheet. Orientation points are two rods, one at each end of the Field House, plainly labeled and visible from all stations. Four rods not plotted on the given sheet are located on the walls of the Field House at varying elevations (shown on Figure 2, labeled Rod A, B, C, and D). Each cadet is then assigned a station indicated on his plane table sheet and is given the elevation of the base of Rod A. He is then required to properly set up the plane table, orient the board, plot on the sheet the horizontal locations to scale of points A, B, C, and D, and to obtain the elevations of Rods B, C and D with respect to the given elevation of Rod A. Supervision, control and grading of this problem can be easily accomplished by the instructor for the large number of cadets under his jurisdiction by using a check overlay.

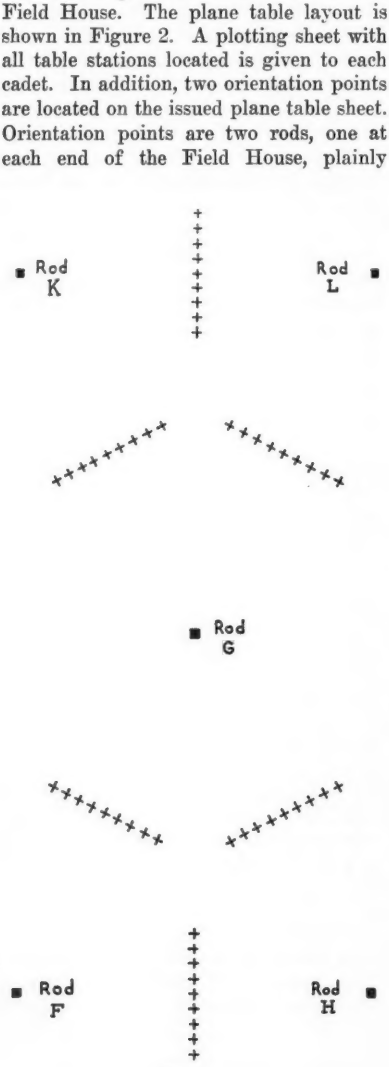



FIG. 3.

c. Level—Two level circuits of three stations each are laid out at the opposite end of the Field House from the transit layout, as shown in Figure 3. Two circuits—one FGH, the second GKL—are necessary to accommodate the large number of cadets taking the exercise simultaneously. Levels are placed on the lines indicated by the x's in the figure. Originally cadets carried an assigned instrument from set-up to set-up between the rods while making the circuit. This past year, to eliminate confusion, instruments were left in position, with cadets using any available instrument at each station. Instructors insured that each instrument was thrown out of level after each use. Rod G is considered to be placed on a bench mark of known elevation. Cadets are given the elevation of Rod G, are then required to run the circuit of three rods, computing and properly recording the notes for elevations of Rods K and L, then closing back on the bench mark, Rod G. To complete the requirement, they are required to adjust the circuit for any error of closure.

Each performance test—transit, plane table, or level—is scheduled for one hour's completion. Each cadet is scheduled to take each test twice at the completion of the field work. A repeat on each problem is given to encourage the cadet to

discuss his errors of the first performance with his classmates in an effort to learn and improve his instrument techniques for the final attempt. In many cases the more apt cadets give perfect performance on the first trial. In this case they are given a bonus score of 100% for both first and second tests and are not required to repeat a perfect performance.

The Field House set-up is geared for mass production, since there is an average of 600 students taking the course each fall. In order to quickly execute the exercises, the class is divided into quarters, with about 150 students participating simultaneously. To accomplish this, each individual type instrument set-up is designed to handle one-third of the 150, or 50 students per hour.

*Conclusion*

We have found the tests extremely beneficial, particularly in forcing our cadets to handle the instruments themselves in lieu of leaning on a more apt member of a party group. We believe it definitely establishes an indication as to which student understands the basic operations of the instruments, combined with the application of the theoretical classroom work.

# Summer Schools

This year the Society will sponsor six Summer Schools, the largest number ever sponsored in any one year. These include:

Machine Design sponsored by the Mechanical Engineering Division, E. E. Ambrosius, *Chairman,* Pennsylvania State University.

Humanistic-Social Studies, S. P. Olmsted, *Chairman,* Rensselaer Polytechnic Institute.

Graduate Study by Engineering Mechanics Division, H. R. Lissner, *Chairman,* Wayne University.

Engineering Economics sponsored by the Engineering Economy Committee, A. Lesser, Jr., *Chairman,* Stevens Institute of Technology.

Electrical Engineering, L. V. Bewley, *Chairman,* Lehigh University.

Summer School sponsored jointly by the General Electric Company and the Educational Methods Division, R. L. Sweigert, *Chairman,* Georgia Institute of Technology.

For information concerning these Summer Schools, please write to chairmen at the above addresses.

In addition to these Summer Schools, there will be a one-day conference sponsored jointly by the Instrument Society of America and ASEE on Saturday preceding the Conference on the general subject of the teaching of instrumentation.

# Education Beneath the Surface

By R. B. DAVIS

*Assistant Professor of Mathematics, University of New Hampshire*

I should like to make three points of quite different sorts:

1. There is frequently a great need in universities to integrate separate departments and to develop "border-line" or "inter-disciplinary" areas of knowledge. One sees a great contrast between different universities in this respect.

In some, a student learns differentiation of $x^n$ in calculus on Monday, say, and uses it in physics later that same week. The physics, mathematics, and engineering textbooks are perhaps even written explicitly for use together, and notations and order of topics are correlated.

In other universities, however, there are gaps between different courses or departments which most students are never able to bridge. There may be no course in mathematics which meets the needs of an electrical engineer. A student may learn calculus, then not use it in physics; or, if it is used at all, either the notations may be so different that the student must use one and forget the other, without being able to combine them effectively, or else perhaps there may be a gap of a year or so between courses, so that the student forgets differentiation before he has any opportunity to use it in physics and engineering. Possibly the student learns more mathematics than is used in his other courses, even where it would fit in quite naturally. Teachers of some courses are likely to be unaware of the definitions, methods, and notations for closely related material presented in other courses. The physics, mathematics, and engineering departments may all have different notions of what a vector is, for example.

The effect on the student is to make studying vastly more difficult for him, to give him the idea that much of what he has been taught is useless "in practice," and to prevent him from achieving facility in the use of mathematics in his engineering work.

### *Learning Under Pressure*

2. Students are not able to learn deeply or profoundly under pressure. "I'd like to understand this," a student says, "but if I try to understand it fully it will take too long. In order to be ready for next week's quiz, I shall merely learn the technique by rote."

Some will say that putting pressure on the student is necessary, otherwise he will not learn. Others may say that we must face rote teaching, in certain cases at least, as one of the unpleasant necessities of life. I believe, however, that teaching and learning by rote have extremely little place in a proper university education, engineering or otherwise. I think that a tremendous amount of progress can be made in teaching the student to *understand*; we do not need to rely on rote in our teaching so much as some instructors imagine. Just how we can escape rote, just how we can replace it by something better, is perhaps one of the most exciting areas of scientific investigation at present, involving the work of many teachers, psychologists, and other specialists, such as Nathaniel Cantor, Carl Rogers, Lawrence Kubie, and William Alanson White. This is essentially a new area, but its promise is already great. One thing that is clear is that we must *remove* some of the pres-

sure from students if we want them to learn things profoundly. Over-frequent examinations or over-bearing professors are effective obstacles on the road to genuine understanding.

### *Learning Cannot Be Imposed*

3. Learning must be done by the student himself. A faculty cannot impose learning upon students, cannot imprint it there with a rubber stamp procedure. Teaching must build upon the student's own opinions and his own experience; these can and usually must be modified greatly as a result of the educational experience. They cannot, however, be modified by a faculty that lectures to the student. The student must learn for himself.

This requires three things of a faculty member: (1) he must respect the student, and respect the student's experiences and opinions; (2) he must know how to lead the student to change these opinions by new experience in college and afterwards; (3) he must not take the initiative away from the student.

These are difficult matters for the faculty member; the student frequently invites the professor to take complete charge, to reduce everything to a matter of rote. On such an occasion, the professor must steer between two shoals, saying to himself: "If I do take complete charge, if I use my judgment and do not require the student to use his, there will be no genuine learning for the student. He will watch, imitate, and later forget. I must make him decide this question for himself. But, on the other hand, if I do *not* take the initiative, the student may feel that I have let him down."

The most satisfactory answer seems to be for the professor to use the warmth of his personality to provide reassurance and support, but to insist that most of the initiative come from the student. Good teachers often do this instinctively. They don't tell the student the answer, nor do they tell him how to get it, but instead they lead him to discover the method for himself.

This can be taken into the organization of the course, as well as into the detailed solution of problems. It is usually desirable to do so, since the over-all atmosphere in a course is far more important than any of the details. An over-all atmosphere of student initiative, as opposed to dependence upon the instructor, can often be furthered by an arrangement whereby students determine the dates of examinations, select the homework assignments, and set the pace for the course. They then know *why* they are studying a particular topic, they know what they expect to get out of a certain problem. Moreover, undesirable dependence upon the instructor, or resentment at being continually manipulated, is minimized by an atmosphere where the student makes many of the decisions concerning the organization of the course.

### *Atmosphere Is Important*

In this, again, the atmosphere is the important thing. It's not what you do, it's the way that you do it. If the professor is alive with his subject, if he is warm and sympathetic to students, he need not fear that the classwork will lag. Virtually every student responds to a friendly, creative atmosphere, and approaches the work with enthusiasm and ambition.

In college we frequently tell the student what to do, we tell him how to do it, and when he has done it, we tell him how well he has succeeded. I believe this is a mistake. More of this should be left up to the student himself. After all, no one becomes a good, productive scientist, engineer, teacher, or citizen because someone else forces him to. Only his own initiative and sense of values can possibly do the trick.

# An Analysis of Mineral Industry Engineering Curricula *

By J. D. FORRESTER

*Professor and Chairman, Department of Mining Engineering, Missouri School of Mines and Metallurgy*

This analysis has been prepared by the writer in his capacity as chairman of a committee which was appointed in October 1952 by Dean James R. Cudworth, Vice Chairman, Southeast Section, American Society for Engineering Education. The objectives of the committee have been to study and report concerning the engineering curricula to be established in universities and colleges for pursuit of training for professional work in the minerals industry. Other committee members are Professors A. V. Corlett, C. S. Crouse, R. T. Gallagher, N. H. Manderfield, H. H. Power and Dean J. P. Spielman.

The committee work has developed as a result of a resolution formulated at the Dartmouth College meeting of the Mineral Division, ASEE in June 1952. The action was: "Resolved that the officers of the Mineral Division study the desirability of starting studies to determine the minimum curriculum requirements for accrediting purposes for various groups within the Division." The interpretation subsequently placed upon the above directive by the officers of the division is one wherein the committee specifically has been charged to accomplish the following:

A. Establish the branches within the division which should be classed as "engineering."

B. Establish minimum curriculum requirements for these branches.

* Presented at the Annual Meeting of ASEE, Univ. of Florida, June, 1953.

A. *Branches of Work of Engineering Character in Mineral Industry Education.*

It is necessary and desirable that "engineering" be defined before an analysis is undertaken to fix what work is of such scope in the Mineral Industry. There are many definitions of the term—some of broad nature and some more restrictive—but, on thorough study, it is apparent that all incorporate the following elements:

1. Engineering is a profession in which men apply the physical sciences creatively to meet the needs and wishes of their society.

2. Engineering is a profession in which science is practiced for economic gain.

As stated by Dean S. C. Hollister, "An engineer is characterized by his ability to apply creatively scientific principles to synthesize, develop or design structures, machines, apparatus, or manufacturing processes, or works using them singly or in combination; or to construct or operate the same with full knowledge of their design, and of the limitations of behavior imposed by such design; or to forecast their behavior under specific operating conditions; all as respects an intended function, economics of operation, and safety to life and property."

On the basis of the above and with specific reference to the Mineral Industry, it is found that areas of professional engineering enterprise are logically divisible

into three major spheres of endeavor, namely:

1. The exploration, discovery, and prospecting of new mineral deposits of the earth's crust.

2. The production and development of known mineral masses occurring in and on the earth's crust.

3. The beneficiation and processing of mineral substances that have been produced from the earth's crust.

Any engineering activity related to the procurement or control of mineral materials (including oil, coal, water or natural gas) is a function within the general scope of one of these major spheres of work. Therefore, this committee proposes that the Mineral Division of the American Society for Engineering Education recognize and establish the existence of three basic major mineral engineering branches, namely:

I. Mineral Exploration Engineering.
II. Mineral Production Engineering.
III. Mineral Process Engineering.

Although the committee is fully cognizant of the fact that mineral industry nomenclature is deeply entrenched by usage, etc., and hence, it may be somewhat difficult to accomplish the immediate, widespread acceptance of the proposed new names, it (the committee) is equally of the opinion that much of our so-called designatory terminology simply is inherited from the past and in reality often is poorly descriptive of modern viewpoints and practices. If the above branches are accepted as the primary or basic divisions of mineral engineering, they will prove to be restrictively unique but, at the same time, of such compass as to be logically inclusive of special professional fields or interests. Findings by others who have studied and written about mineral engineering curricula, when correlated generally with those of this committee, lead to the recommendation that mineral engineering branches and their respective particular curricula should be adopted, as follows:

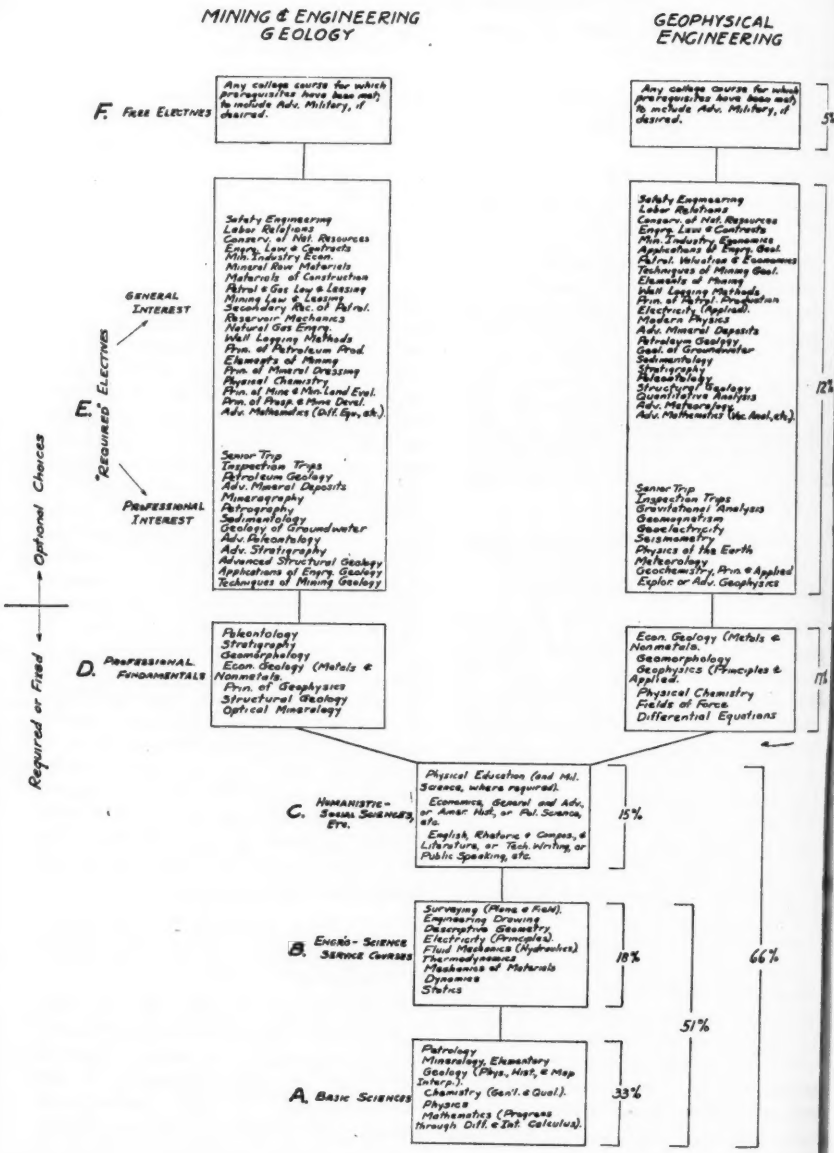
I. Mineral Exploration Engineering.
   A. Mining and Engineering Geology.
   B. Geophysical Engineering.
II. Mineral Production Engineering.
   A. Mine and Quarry Engineering.
   B. Petroleum and Natural Gas Engineering.
III. Mineral Process Engineering.
   A. Metallurgical Engineering.
   B. Mineral Dressing.
   C. Ceramic Engineering.

Each of the above mineral industry curricula is of such character as to be recognized as of engineering scope because each will stand critical analysis on the basis of the accepted definition of the term "engineering." That is, each given curriculum essentially incorporates the necessary elements which comprise Dean Hollister's statement. At this time, the committee believes that above list of mineral industry curricula is sufficient and proper. However, it can be enlarged or expanded in any particular branch should progressive changes develop in mineral engineering technology to warrant extension. It should be realized by the reader that adoption of the above proposals concerning Mineral Engineering branches and curricula will not require a school to modify markedly its presently established "plan of operation." That is, in any given institution, it will be possible still to designate Petroleum Engineering as a specific field; Mining Engineering will maintain as an engineering curriculum; Ore Dressing will continue as an entity, etc.

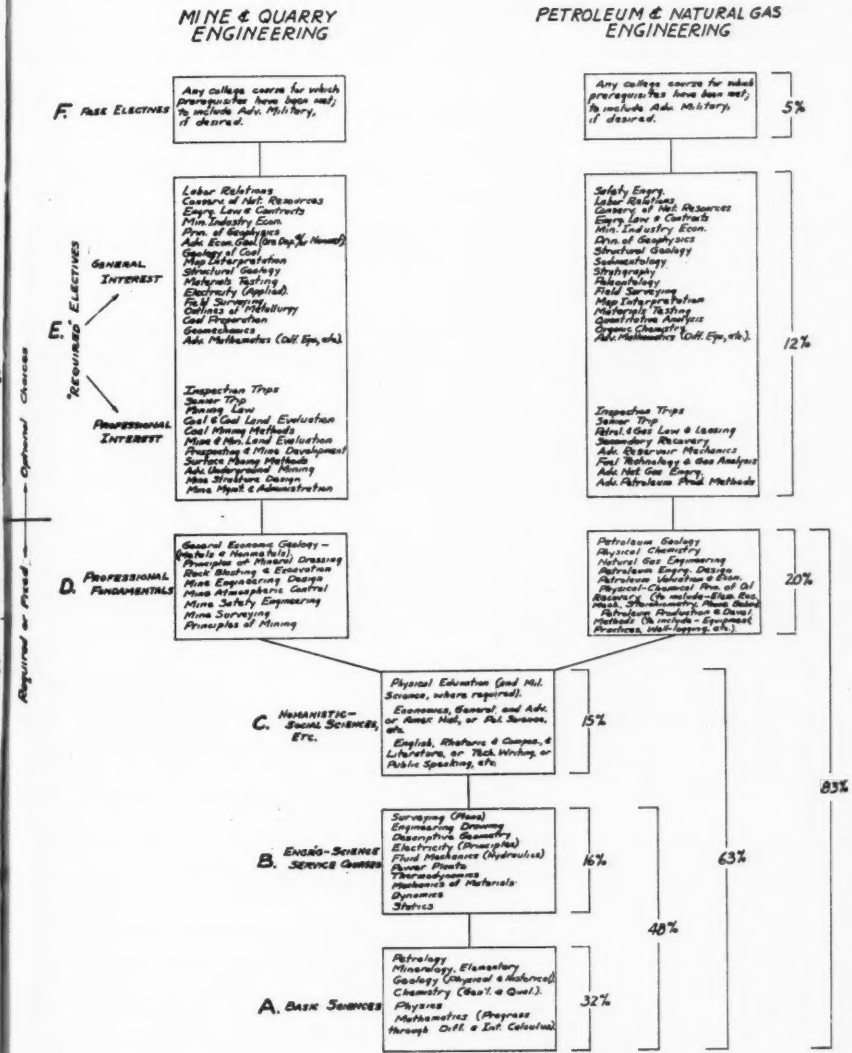
B. *Curriculum Requirements of the Engineering Branches of Mineral Industry Education.*

In the writer's opinion, there are several features that must attend any satisfactory engineering curriculum. Each is essentially of equal importance in the accomplishment of full, well-rounded training for professional service and citizenship. These objectives, in the final

## I- MINERAL EXPLORATION ENGINEERING



## II- MINERAL PRODUCTION ENGINEERING




analysis, are the ends sought by academic endeavor. The features are, namely:

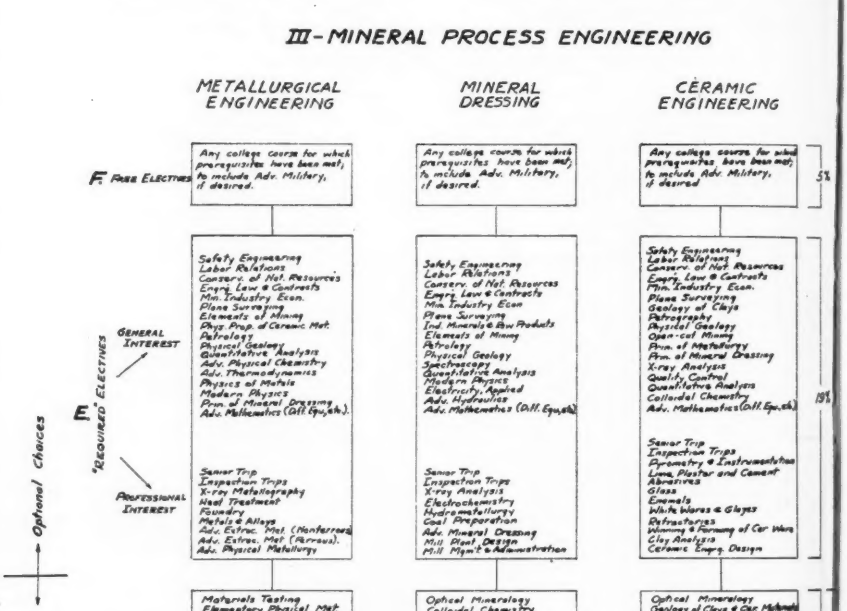
1. At least a modicum of specified training in culture such as literature, history and economics as the bases for assumption of citizenship responsibilities.

2. A sufficient requirement of study in basic sciences and engineering sciences to

insure an able, thorough understanding of how such knowledge is applied to engineering, in general, and to a given branch, in particular.

3. A fundamental training in a given engineering field to prepare the individual with a foundation for successful professional practice.

4. Optional studies whereby the student, with qualified guidance, can select



a special channel of professional work for which he has a particular desire or aptitude.

5. A reasonable opportunity to gain knowledge of any sort in any field of interest that may be available for study in the given university or college. For example, the work can be, on occasion in such "foreign" or professionally remote subjects as music appreciation or drama. Contrary to the point-of-view held by many, it is the writer's belief that studies of this type may be as interesting, beneficial, and broadening to the engineer as they are to other students.

This analysis of minimum requirements for mineral engineering curricula has been predicated on the philosophy fixed and defined by the above controlling elements. As shown by the accompanying charts, all curricula within any major branch have a common root of:

A. Basic Sciences.
B. Engineering—Science Service Courses.
C. Humanistic—Social Sciences.

The various optional fields of interest in any particular curriculum are, in turn, so related as to have a common stock in D. Professional Fundamentals. For example, Blocks A, B, C, and D, as they have been developed for each curriculum and so depicted on the respective charts, are fixed for that curriculum. As a case in point, any Ceramic Engineer, regardless of whether his interest is specialization in Glass, in Refractories or in White Wares, etc., must have the basic training (Blocks A, B, C, D) common to all Ceramic Engineers.

A parallel situation is true for Mining Engineers and other specified curricula of all branches; a coal mining major will take the same basic training (Blocks A, B, C, D) as a man primarily interested in metal mining. The specialization, in any case, will develop by the judicious, guided selection of the courses designated as "Required" Electives in Block E and subjects listed there are to be chosen by the student in conference with his adviser. The selection for fixing a given curriculum should be pro-rated from both the Professional Interest portion and the General Interest section of the block, as a whole. That is, an ideal curriculum becomes one with a suitable, selected balance between the two portions of Block E. The Free Electives of Block F will allow for work in Advanced Military or will permit a nominal unrestricted choice of study in any field of interest regardless of the so-called foreign character it may have.

The procedure outlined above has an inherent flexibility and a student with particular talents, aptitudes or desires thus is able to enjoy the opportunity to extend and direct his academic training while he is simultaneously acquiring a basic, required engineering knowledge. The reader will note that some subjects such as Quantitative Analysis, and Wet and/or Fire Assaying are not included as requirements in some curricular areas where often they have been previously placed. The primary reasons why these deletions have been made are: a. These courses are usually of "cook book" character rather than of engineering caliber, at least so far as the method of presentation is concerned. b. Progress in technology and its engineering application no longer requires such work as might have been deemed necessary some years ago. For example, the present-day lack of a need of assaying technique by the practicing Mining Engineer is a case in point.

It seems to be the consensus among educators that at least 4 academic years of college study are necessary to train mineral engineers of any branch. This commonly results in the acquisition of a total of about 150 credit hours wherein 1 credit has been earned for each recitation-lecture hour a week and 1 credit has been granted for each 3-hour laboratory period a week. The distribution of work may be made on the basis of the so-called semester plan or the quarter system. In any case, it involves about 8½ months of college study during each year of a 4-year

period. The actual time devoted to instruction through each of the 8½ month periods approximates 32 weeks. However, because the total of credits required for a B.S. degree is not standard in all schools, the logical approach to an overall analysis of the type that is here undertaken is to allocate the various units of training on a percentage basis. This is a legitimate and necessary procedure as the range of hours that develops is not primarily because of major differences in the character of courses but rather is in the number of hours devoted to specific subjects. The various items of subject matter given on the charts are to be construed to represent the nature of recommended course work rather than necessarily being particular courses. That is, one school may see fit to identify some subject material by slightly different terminology than another institution and, hence, an effort generally has been made to make the chart listings those of descriptive character instead of specific designations.

The percentages of study depicted for various units on the charts should not be interpreted as being absolutely inflexible. This is because it is recognized that some leeway of one, two, or even three percentage points may exist in any given study area of mineral engineering at any particular school. Such a situation does not imperil the pertinency of this present analysis nor does it necessarily reflect an unacceptable or untenable balance of subject matter at the given academic institution where slightly different percentage relations may be in effect.

The writer has studied the controls which theoretically are applied in evaluating Chemical Engineering curricula. These statistics, as listed in "The Development of Chemical Engineering Education in the U. S. by the Committees on Chemical Engineering Education of the A.I.Ch.E." (p. 21), are:

| | |
|---|---|
| Chemistry | 25–30% |
| Chemical Engineering | 20–15% |
| Other Engineering | 12% |
| Mathematics | 12% |
| Physics | 8% |
| Mechanics | 6% |
| Other Sciences | 2% |
| Cultural Subjects | 15% |

The analysis of these percentage data by breaking them down as logically as possible into comparable units with those which have been used in this present study and, similarly, by taking an average of the units of the three major Mineral Engineering branches, gives the following comparison:

| | Chemical Engineering | | Mineral Engineering |
|---|---|---|---|
| A. Basic Sciences | Chem. 25%, Physics 8%, Math. 12% | 45% | 31% |
| B. Engineering-Science Service Courses | Mech. 6%, Other Sci. 2%, Other Engrg. 12% | 20% | 17% |
| C. Humanistic-Social Studies | | 15% | 15% |
| D. Profession Fundam. | (Chem. Engrg.) | 20% | 17% |
| E. "Required" Electives | | 0 | 14% |
| F. Free Electives | | 0 | 5% |
| | | 100% | 99 + % |

So far as is known, Chemical Engineering is the only field of engineering training in which curricular requirements previously have been established and specifically given. It is apparent that such controls as have been used for evaluating and accrediting this branch of engineering are much more inflexible than those herewith proposed for all branches of Mineral Engineering. As previously discussed,

this rigidity of a course of study is, in the writer's opinion, an undesirable characteristic. Anyone who is well educated in engineering is trained in the basic sciences, and in special professional areas and, likewise, has had an opportunity to acquire some background of learning as a reasonably cultured citizen. A fully educated person has not been developed if any of these essential elements are lacking.

*Conclusion*

The foregoing text of this report proposes:

A. Branches of work that should be recognized as of enginering character in Mineral Industry Education and;

B. Minimum course-of-study requirements that should obtain to in any curriculum of Mineral Industry Education.

Your committee recommends the adoption of the proposals by the Mineral Division, ASEE. If this recommendation is accepted, it means, of course, that any school seeking accreditation will be expected to meet the various designations and respective curricular requirements. Thus, guides will be available to engineering institutions to aid in establishing curricula and, likewise, examining boards will have controls in effect to govern their decisions concerning the status of courses of study.

**ANNUAL MEETING**

***June 14-18, 1954***

**University of Illinois** **Urbana, Illinois**

# Is Closer Integration an Answer to Crowded Curricula?*

By PROFESSOR JOHN J. TURIN

*Head of the Department of Physics, University of Toledo*

There has been no clear agreement on the basic objectives of the undergraduate engineering curriculum. There are many opinions and a wide divergence in ideas. There are some who think the training should be broad and basically scientific with added specialization in post-graduate work. Others think the program should be highly specialized because of the necessity for presenting a vast amount of information in each field of specialization. Some insist that the engineer needs far more exposure to the humanistic and social studies. Many agree, but argue there just is not the space available in the already crowded curriculum.

Primarily we are faced with the problem of determining the objectives of engineering education in a civilization whose complexion is changing at an extremely rapid rate. Engineering educational objectives must be realistic and malleable. They must take into account the technological changes of our times, but they cannot be all inclusive. Similarly they must not be oblivious to the social impact of our technical progress, nor can they ignore the impact of these changes upon the student.

There are many pressures caused by a variety of different problems, each of which will ultimately exert its influence in determining the objectives of future curricula in undergraduate engineering education. The literature is abundant with discussions, each trying to give proper weight to some one of a number of factors important in the training of engineers. No doubt evolution and necessity will gradually produce clarification and more common agreement regarding the objectives of engineering curricula.

There seems however to be general agreement that the engineering curriculum is crowded. So crowded in fact, that there appears serious doubt as to whether it is possible to include even short introductions to some of the basic new concepts which have recently developed in the engineering field. As a matter of fact, the inclusion of any new topic requires the exclusion of a topic presently in the curriculum, and this of course, raises questions regarding the relative importance of each subject.

No matter how we change the basic objectives of engineering education over the long term, we all realize that what can be done in the various specialties and on the higher level is influenced to a great degree by the preparation of the student in the high schools and in the introductory courses to the engineering curriculum. We would all agree that many of our curricular problems would fade if the entering student were better prepared. Quite obviously we are not free to determine college entrance requirements in a fashion oblivious to the problems of the high school, but MacDonald [1] and Rose [2] are

* Presented at the Ohio Section Meeting of ASEE at Cincinnati, May 2, 1953.

[1] MacDonald, C. E., "The Future Prospects of Improved Preparation for College," *Journal of Engineering Education*, 42, p. 432 (1952).

[2] Rose, L. A., "A Joint Attack on the Mathematics Entrance-Requirements Prob-

encouraging along this line. Certainly we must extend a cooperative hand to the high schools and help to raise the level as well as the interest of the entering engineering student.

In our college curricula perhaps we should consider a closer integration of the introductory engineering subjects to obtain a more efficient use of the early years, thus effectively lengthening the period for higher level training.

### *The Thinking Process*

There is one basic educational objective which too often we take for granted. The engineer *must learn to think properly.* For if he fails in this, all other items in his training are of secondary importance.

The thinking process is complex, and must be clearly distinguished from the "ability to read, to listen and to retain facts."[1] Doughtery[3] suggests:

> "To teach one to think is the highest possible teaching achievement. It comes from a combination of understanding, memory, association, application of laws, and ability to sense possible relationships."

All agree that the educational processes leading to the prevocation and practice of thinking must be encouraged from the earliest possible moment. Yet our curricula are not too often calculated to help the process, and often do the opposite.

The "technical thinking" of the engineer is a highly specialized process, which requires a clear and concise appreciation or how mathematics and a fundamental understanding of natural phenomena can be fused together and applied to tasks of usefulness and value to society with a minimum of "cut and try." To develop this thought process requires a proper cultivation of the "will to do" and a realization on the part of the student that mastering this thought process will help simplify his problems and not constitute an added difficulty.

A closer integration of the introductory courses with the objectives of bringing the student to a more confident and more mature development in "technical thinking" at the earliest possible time should be worthy of careful consideration. For what the student is taught at the start is the basic platform upon which all else must stand. It is essential that the student be introduced to proper and productive thought discipline from the very beginning so that it will not be necessary to apply successive and alternative corrective procedures.

From this standpoint, perhaps we have been giving far too little attention to the introductory portions of engineering education and concentrating too much on how we can get adequate coverage in the more specialized fields of engineering.

### *Introductory Courses*

Barker[4] suggests that we abandon the idea that elementary and introductory courses should be taught by junior instructors and teaching assistants. For here is the most difficult job, and where we can make the greatest gain.

There is good reason to insist that the introduction to engineering must be given by our most experienced and mature minds, by those who are intimately familiar with the purposes of the introductory courses and the nature of the problems the student will ultimately encounter in pursuing his engineering goals.

It is imperative that the objectives of the introductory courses, and the disciplines which they encompass be brought to the student in an inspiring way, provocative of thought. In this way the student will enjoy these introductory courses and come to an earlier appreciation of the value of the disciplines inherent in them. He will be more confident that he has acquired a useful ally and a friend,

lem," *Journal of Engineering Education*, 42, p. 412 (1952).

[3] Doughtery, N. W., "Educational Maturity is the Goal," *Journal of Engineering Education*, 41, p. 271 (1951).

[4] Barker, George J., "Four Year vs. Five Year Engineering Course," *Journal of Engineering Education*, 42, p. 460 (1952).

and will not look upon the introductory courses as just another obstacle he must overcome.

If the elementary preparations are adequately achieved and the discipline of mathematics is properly integrated into the "technical thinking" process during the introductory courses, the advanced subjects can be mastered more easily by the student and in less time without constant repetition and duplication.

As an example, too often the student thinks of his mathematics and physics as something apart from engineering— a necessary evil which he must put up with in order to be allowed to study what he is really interested in—and something to be forgotten at the earliest possible moment.

As accumulated knowledge increases the various aspects of engineering become successively more highly technical, and should the pace of progress continue, this will become more and more magnified as time goes on.

This situation requires of the student an ever greater familiarity with applied mathematics and physics on a higher and higher technical plane if he is ultimately to cope with the new engineering problems which will confront him.

### *Costly Methods*

During the past years because of the immaturity of the student in applied mathematical thought we have used methods for teaching physics and engineering subjects which circumvented the need for a proper understanding of applied mathematics even in its most simple forms. These methods are extremely costly in time, and it is questionable whether we can longer afford the luxury of taking extra time to teach and re-teach an engineering principle that can be taught with greater rigor and better understanding if the student's command of applied mathematics and physics has been properly developed.

It seems reasonable to believe that a fundamental contribution can be made generally to all engineering curricula by giving careful attention to the introductory courses and applying the necessary measures which will result in a close integration of the introductory courses to the ultimate specialized subjects.

Experience certainly indicates that if mathematics and even physics are taught as pure sciences without detailed reference to engineering application, that it is difficult thereafter to demonstrate to the student how these sciences can be fruitfully considered a basic part of engineering.

There is no time for details in a short discussion such as this. However any measure which can help the student to a more mature mind earlier in his college training will enable him to learn more quickly. Within limitations of course, closer integration of the introductory courses to the engineering courses can have the effect of lengthening the time for study and therefore easing the crowded curriculum. This procedure should additionally help the student to acquire at an earlier date that "judgment" [5] which is so essential to the successful engineer.

[5] Sherwood, Thomas K., "Should Engineering Schools Teach Engineering?", *Journal of Engineering Education*, 43, p. 383 (1953).

# The General Mode of Analysis in Engineering Education*

By L. M. K. BOELTER, *Dean of Engineering, University of California at Los Angeles*
and
G. A. HAWKINS, *Dean of Engineering, Purdue University*

The undergraduate engineering student is constantly confronted with the analysis and synthesis of engineering problems from the time he enters the freshman year until graduation. Many of these young engineers do not appreciate the fact that there is a general mode applicable to many areas of engineering; and hence develop an attitude of mind that each type of problem is solvable only by a special technique. It is, therefore, important in the educational experience of the engineering student to introduce the general mode early in the program and continue a thorough integration of the basic mode throughout all of the remaining work. By continuous employment of the general mode the student acquires skill in its use, and forms a habit which will last throughout his professional engineering career.

The first phase of the program of familiarizing the student with the general mode of analysis is to make him aware of the difference between the actual and the ideal engineering system. Due to the complexity of present day engineering machines, structures, processes, and circuits, it is difficult—and in many instances impossible—to analyze and synthesize them without introducing simplifying assumptions and postulates. In order to consider an actual engineering system the engineer must devise an ideal or mental concept based on certain suppositions, which he then studies in place of the actual device.

As a final step in the consideration of the system, the engineer must predict the behavior of the real or actual system from the results obtained from his ideal or mind system. This latter step requires a great deal of actual experience, which is usually acquired after graduation. Because of limited time and other factors it is only possible to impress upon the undergraduate engineering student the importance of post graduate experience with various engineering systems.

### *Ideal System*

In order to illustrate the use of the ideal or mind system for the prediction of the behavior of the actual system, imagine that the engineering student has been called upon to estimate the elongation of a vertical structural steel bar when acted upon by a given tensile force. Before the student is able to apply fundamental laws or basic facts he must establish an ideal system based on postulates such as the following: the tensile force is applied along the exact longitudinal axis of the bar; no bending of the bar occurs; the bar material is homogeneous; the thermal environment surrounding the bar remains constant; all elemental fibers of the bar undergo the same elongation; the proportional limit of the materials in the bar is not exceeded; the weight of the material is negligible in comparison to the load.

Having established a mental picture of the ideal system, the student is in a position to apply Hooke's experimental law

* Paper prepared for the sixty-first Annual Meeting of the ASEE, June 22–26, 1953, Gainesville, Florida.

and predict the elongation of the ideal bar. Based on previous experiences with other actual systems (this may be lacking as far as the student is concerned), he must decide as to how accurately the elongation of the ideal bar will represent that for an actual rod.

The majority of experienced engineers established the ideal system on the basis of simplifying postulates with little ado. They become so accustomed to dealing with the idealized case that they seldom think of it as a separate step in the procedure of analysis or synthesis.

*General Procedures for Studying the Behavior of Engineering Systems*

Having been introduced to the concept of the ideal and actual systems, it is then possible to show the student how the ideal or mind picture fits into the general procedures used by engineers in the study of complicated engineering systems. It is felt that the six following steps are generally used by engineers in the study of engineering systems:

1. The preparation of a complete statement of the problem associated with the actual system.
2. The establishment of an ideal or mind system based on
   (1) direct observations or a familiarity with the actual system,
   (2) direct observations or a familiarity with similar ideal or actual systems.
3. Specification of the boundaries of the ideal or mind system.
4. The application of the fundamental laws or basic knowledge in order to obtain the behavior of the ideal or mind system.
5. The prediction of the behavior of the actual system from the results obtained on the ideal or mind system.
6. The study of additional ideal systems if greater accuracy is required in predicting the behavior of the actual.

The results obtained using the first ideal system may not be sufficient in extent or have the desired accuracy in order to predict the behavior of the actual system. In this event a second mind or ideal system must be formulated and analyzed on the basis of fewer or new postulates. As the number of mind systems is increased the behavior of the actual system may be more accurately portrayed from the analysis of the ideal cases. From a theoretical standpoint, if the number of mind systems becomes infinite, the behavior of the actual and ideal systems become one and the same. The number of ideal systems which an engineer may wish to use will depend upon such factors as economic limitations, available time, the knowledge of the engineer, and the knowledge of society in general.

The general mode of analysis becomes unique to engineering when the solutions are considered in terms of time, cost, materials, and men. For example during war periods, time and men may be more significant than cost or materials, hence the engineer must give serious consideration to these factors in his analysis.

*Specific Modes of Analysis*

Specific names may be used to describe the general method of study by referring to the laws and knowledge employed in the fourth step. If basic economic laws are applied, then the method could be termed the economic mode of analysis. The mode of analysis used by engineers in the study of energy conversions may be termed the "thermodynamic method of analysis," and would encompass the application of the laws of thermodynamics in step 4.

*Approaches Used in the General Mode of Problem Solution*

Having impressed upon the student the importance of the general procedure, it is important to acquaint him with the four procedures used by engineers, which follow:

1. *Analytical*—The analytical approach consists of applying and solving mathe-

matical equations based on physical laws. By employing suitable techniques and computing facilities, satisfactory solutions for the equations may be obtained for use in predicting the behavior of some engineering systems.

2. *Experimental*—This approach covers experimental determination and prediction of the behavior of the engineering system.

3. *Art*—In many problems encountered by the professional engineer the force fields may be very extensive or even unknown, and hence they cannot be treated analytically or experimentally. In these instances the knowledge of the engineer, which may be based on scientific training and greatly amplified by practical experiences, enables him to predict the behavior of an actual system. The professional engineer is able to sense the variables involved, which cannot be analyzed or formulated by the scientist who lacks his experience. Usually the engineer has available a large amount of unformulated knowledge gained by experiences with many actual systems upon which he may draw.

4. *Models and Analogues*—This approach consists of establishing a model or analogue which may be used to predict the behavior of the actual system. In many instances the model method is used in conjunction with the experimental and analytical methods.

In the study of many engineering problems it is often necessary to use a combination of two or more of the methods in order to predict the behavior of the actual system. The ability to use the four methods independently or in combinations greatly expands the engineer's skill to predict the behavior of an actual from an ideal system.

Too often young engineers acquire a feeling that one of the four methods is superior and more important than all of the others. It is our responsibility as practicing engineers to help and encourage engineers in training to become proficient in the use of the four methods. In so doing we will enhance their education and strengthen the profession.

Before successful integration of the general mode can be attained, the complete cooperation of the individual faculty members must be obtained. Unless the staff members are sympathetic toward the educational project, very little can be accomplished. The student can only acquire the necessary skill in the use of the general mode if the instructors in the freshman, sophomore, junior, and senior years insist upon the application of the basic principles to the solution of problems in their particular courses. Only after employing the principles in various courses will the student acquire the necessary skill and confidence in the system of analysis and synthesis.

# New Members

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DE CHAZAL, LOUIS EDMOND MARC, Assistant Professor of Chemical Engineering, University of Missouri, Columbia, Mo. R. H. Luebbers, H. O. Croft.

CROSS, RAYMOND EDWARD, Instructor in Management, DePaul University, Chicago, Ill. R. S. Lindenmeyer, B. H. Jennings.

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269 new members elected this year

# Section Meetings

| *Section* | *Location of Meeting* | *Dates* | *Chairman of Section* |
|---|---|---|---|
| *Allegheny | University of Pittsburgh | April 30–May 1, 1954 | W. I. Short, University of Pittsburgh |
| Illinois-Indiana | Illinois Institute of Technology | May, 16, 1954 | R. G. Owens, Illinois Institute of Technology |
| Kansas-Nebraska | University of Nebraska | Fall, 1954 | M. H. Barnard, University of Nebraska |
| Michigan | University of Michigan | May 8, 1954 | F. L. Schwartz, University of Michigan |
| Middle Atlantic | Lafayette College | May 8, 1954 | C. Bonilla, Columbia University |
| Missouri-Arkansas | Missouri School of Mines | April 10, 1954 | V. J. Blum, St. Louis University |
| National Capital Area | Library of Congress | Feb. 2, 1954 | C. H. Walther, George Washington University |
| New England | Massachusetts Institute of Technology | Oct. 9, 1954 | E. R. McKee, University of Vermont |
| North Midwest | Marquette University | Oct. 9–10, 1953 | A. B. Drought, Marquette University |
| Ohio | Ohio State University | May 1, 1954 | R. S. Paffenbarger, Ohio State University |
| Pacific Northwest | Oregon State College | April 23–24, 1954 | L. Slegel, Oregon State College |
| Pacific Southwest | San Jose State College | Dec. 29–30, 1953 | C. M. Duke, University of California at Los Angeles |
| *Rocky Mountain | University of Utah | | A. Diefendorf, University of Utah |
| Southeast | North Carolina State College | March 25–27, 1954 | J. R. Cudworth, University of Alabama |
| Southwest | University of Texas | April 16–17, 1954 | J. J. Heimerich, University of New Mexico |
| Upper New York | Rochester Institute of Technology | October 16–17, 1953 | F. E. Almstead, State University of New York, Albany |

**Members of the Society are welcome at all Section Meetings**

*** No Date Set.**

# Report of the National Security Training Commission on UMT

The National Security Training Commission, appointed by the President to make recommendations respecting Universal Military Training, submitted its report on December 14. This will be considered by Congress shortly after it convenes in January. The principal features of the Report might be summarized as follows:

1. All physically fit males should share in the obligation to serve the nation.

2. The present reserve system has drawn too heavily on veterans of World War II and is therefore unfair. More than 600,000 veterans of World War II who were in the reserve were involuntarily recalled to duty in the Korean War, whereas prior to June, 1950, 2½ million of the 3½ million physically fit young men who became 18 between World War II and the start of the Korean emergency saw no service. This policy is morally wrong and financially costly.

3. If the armed forces are maintained at 3,360,000 which is highly unlikely, through 1960, there will be over 2 million fit young men who will not have served. There are about 1,600,000 fit young men of military age who have not seen service as of now.

4. All fit young men of 18 should be required to enter the National Security Training Pool upon registering with the Selective Service System.

5. After six months of basic and technical training, National Security Trainees would be transferred to the reserve for 7½ years and would be liable to recall ahead of veterans.

6. Veterans of the present emergency who have served two years or more should be transferred out of the Ready Reserve to Standby Status upon request as the national security permits.

7. The reserve obligation of young men who undertake certain professional and technical training should be held in abeyance until the completion of such training, if they so desire.

8. Young men should draw lots upon registering with the Selective Service System to determine whether they will be liable for training or service and should be notified of the result immediately.

9. Permissive deferments now possible under Selective Service would be disallowed for induction for the training period. Students and industrial workers would be given some latitude in deciding when their service or training is to start.

10. Induction of young men in college would be delayed until the end of the current academic year.

11. ROTC students who have signed a contract would be deemed to have fulfilled their obligation for training.

12. National Security training would begin by January, 1955 or earlier, with at least 150,000 trainees.

13. National Security trainees should receive not more than six months and not less than 1050 hours of training.

### *Recommendations of Engineering Manpower Commission*

The Engineering Manpower Commission of the Engineers' Joint Council has recommended that the training period be reduced from six months to four months and that it be coordinated with the college program for individuals interested in higher education. They also recommended that trainees be returned to civilian status after the training period and be subject

to recall only by the Selective Service System. This would make it possible to call up trainees on the basis of the overall needs of industry, the country, and the military services.

They also recommended that study be started immediately of the problem of a voluntary, dependable, immediately available reserve apart from consideration of UMT. The ASEE is working with the Engineering Manpower Commission and the American Council on Education in preparing recommendations respecting this program.

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# Teaching Positions Available

**The following rules were adopted by the General Council of the ASEE:**

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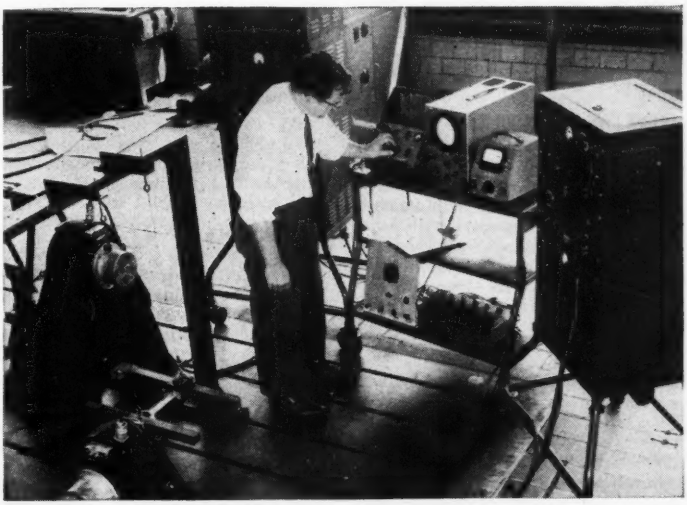

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**INFORMATION**
If you or any of your students would like additional information about engineering careers at Boeing, write to John C. Sanders, Staff Engineer-Personnel, Boeing Airplane Company, Seattle 14, Washington.

A MESSAGE TO COLLEGE ENGINEERING STUDENTS

from J. M. Wallace, Manager, Meter Division, Westinghouse Electric Corporation. *University of Pittsburgh, 1935.*

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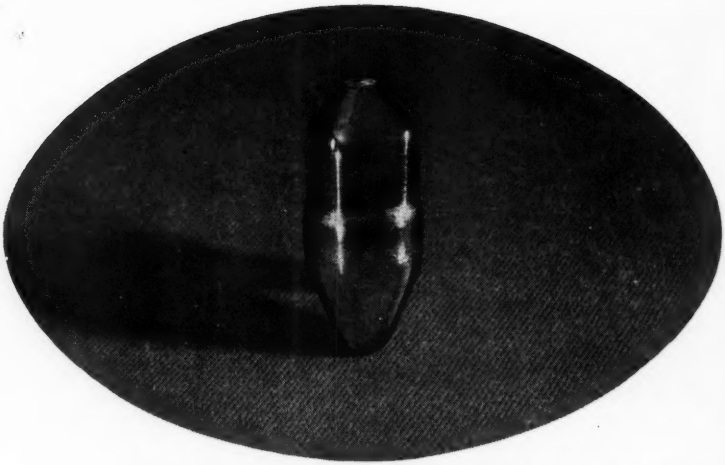

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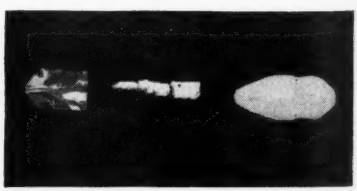

Section of natural germanium, left, shows varying crystal structure. At right is sectioned single crystal grown at Bell Laboratories.

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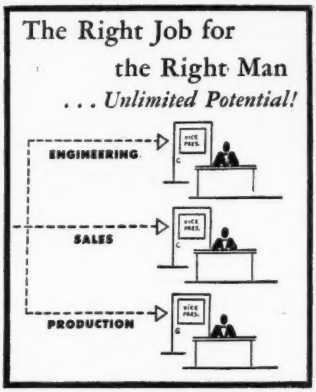


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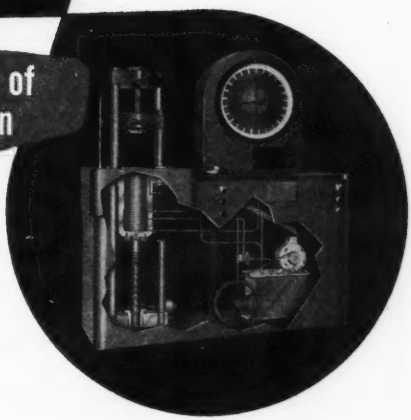

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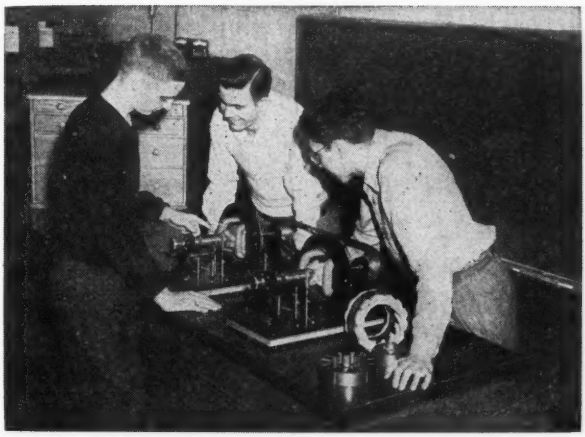

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